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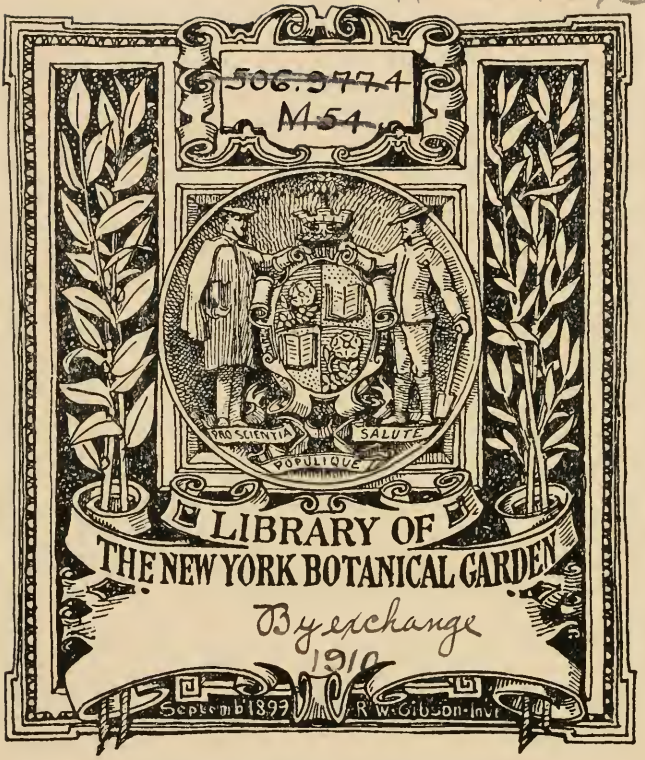
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TWELFTH REPORT

OF

THE MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, MARCH 31, APRIL 1 AND 2, 1910

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY

GEO. D. SHAFER

SECRETARY

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LETTER OF TRANSMITTAL.

To Hon. Fred M. Warner, *Governor of the State of Michigan:*

Sir—I have the honor to submit herewith the Twelfth Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,

GEO. D. SHAFER,

Secretary of the Michigan Academy of Science.

E. Lansing, Mich. May, 1910.

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OFFICERS 1910-1911.

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Librarian, A. G. Ruthven, Ann Arbor.

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Dr. Charles E. Marshall, East Lansing.
Professor Frank Leverett, Ann Arbor.

COUNCIL.

The Council is composed of the above named officers and all Resident Past-Presidents.

MEMBERSHIP OF THE MICHIGAN ACADEMY OF SCIENCE, MAY 2, 1910.

(Charter members are marked with an asterisk.)

RESIDENT MEMBERS.

A

Adams, H. C., Ann Arbor.
Alexander, S., 706 Seventeenth St., Detroit.
Allen, R. C., Lansing.
Anderson, A. Crosby, East Lansing.
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Arnos, Edw. M., Olivet.

B

Baker, Horace B., 210 S. Ingalls St., Ann Arbor.
*Barr, Charles E., Albion.
*Barrows, W. B., East Lansing.
*Beal, Wm. J., East Lansing.
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Blain, Alexander W., 1105 Jefferson Ave., Detroit.
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Brown, George Arthur, East Lansing.
Burnham, Ernest, 509 S. Rose St., Kalamazoo.
Byers, I. W., Iron River.

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D

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G

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H

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Harvey, Caroline C., 151 Winder St., Detroit.
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Holm, M. L., 629 Shiawassee St., Lansing.
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J

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K

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Kraus, E. H., Ann Arbor.

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N

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*Novy, F. G., Ann Arbor.

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R

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Robison, Floyd W., East Lansing.
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S

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T

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W

*Walker, Bryant, 205 Moffat Bldg., Detroit.
Wenzel, Orrin J., LeRoy.
Wetmore, Dr. Mary, Allegan.
*Wheeler, Eben S., 76 Delaware Ave., Detroit.
White, Oliver K., East Lansing.
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Williams, C. B., 214 Stewart Ave., Kalamazoo.
Willoughby, L. P. Ray, Detroit.
*Willson, Mortimer, 6th and Water St., Port Huron.
Winter, Orrin B., East Lansing.
Wood, Norman A., Museum Bld., Ann Arbor.
Wood, L. H., Kalamazoo.
Wright, Luther L., Lansing.

†Deceased.

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Battle Creek Nature Club, Chas. E. Barnes, Pres., Battle Creek, Mich.

REPORT OF THE TREASURER.

April 1, 1909–March 31, 1910.

Receipts:		
Balance on hand	$16 25	
All other receipts	214 50	
Total	$230 75	
Expenses:		
For reprints		$98 75
Postage and envelopes		16 74
Programs, announcements and letter heads		46 85
Dues blanks and membership cards		7 50
Express and dray		1 10
Charles Meyers		6 50
S. D. Magers		10 00
Total		$187 44
Balance on hand March 31, 1910		43 31

WILLIAM SMITH SAYER.

WILLIAM SMITH SAYER.

Mr. Sayer was born on a farm, called the "Sayer Homestead," near Wayne, DuPage county, Illinois, January 13th, 1876. From childhood to his "Academy days" he passed on the farm. He received no other schooling during the first ten years of his life than that furnished by a companionable, intelligent mother, who directed his studies. After his tenth year, he attended the country school till he entered the "Elgin Academy" in 1892. Three years later, he graduated from the Academy and entered Beloit College.

His college days proved a formative stage in his career by developing within him a taste for the association of a college, friends, study, culture—all the features which are constituents of a college atmosphere —and a basic and intuitive love for his home. His home became the retreat for his college chums, his mother, their foster-mother. Both college and home were linked together in his mind and in his life, as inseparable supports to action. Throughout his career, these two factors were prominent, even foremost. His graduation from Beloit occurred in 1899. Ambition of a noble type was aroused in him, and instigated by his parents, he undertook special work in the University of Chicago, choosing bacteriology and chemistry for his chief lines of study. In 1901 he was placed in charge of a laboratory at Grafton, Illinois, by Dr. E. O. Jordan, for the purpose of examining the waters of the Chicago Drainage Canal. With the discontinuance of this work in January, 1902, he returned to the University to pursue the course of study, he had begun, until the autumn of 1902. At this time, he quit the University, but before leaving he had completed all of his work, except the thesis, for his doctorate degree. He entered the employ of the Kennicott Water Softener Company as a chemist. He remained with this firm for four years, and in the spring of 1907 he was called to the Bacteriological Laboratory of the Michigan Agricultural College to undertake research work. His attention was at first centered upon the "Keeping Qualities of Butter," and, conjointly with Dr. Otto Rahn and Miss Bell Farrand, issued the results of the first year's investigations in bulletin form from the Experiment Station.

All of his training directed his tastes into the field of soil investigations. It became possible for him to satisfy his desires with the departure of Prof. Walter G. Sackett for Fort Collins, Colorado. Mr. Sayer picked up the thread where Mr. Sackett dropped it, and centered all of his force in this work.

Mr. Sackett also turned over the office of Secretary-Treasurer of The Michigan Academy of Science to him at the same time, with the consent of the council. At the annual meeting of the Academy, he was again made Secretary-Treasurer, as a recognition of his faithful and efficient services.

While canoeing on the Red Cedar river, a sport very fascinating to him, on the 30th of April, 1909, he was thrown into the river and

drowned. Two weeks later, his body was found and buried from his home in "Little Woods Cemetery," Wayne, Illinois.

Mr. Sayer was careful to painstaking, very systematic, and patient. No truth was too homely for him; he wished no garnishments to cloak the facts. Therefore, what he did was honestly done and what he said was true, so far as he could determine. Such were the strong characteristics of the man.

W. J. Beal,
Charles E. Marshall,
Committee.

CHARLES FAY WHEELER.

Charles Fay Wheeler was born June 14, 1842, at Mexico, Oswego county, New York; died at George Washington Hospital in Washington, D. C., March 5th, 1910, and was buried in Arlington Cemetery.

He graduated from the Academy at Mexico, near where he was born, and enlisted in October 1861, as a private in Company B, Seventh Regiment of the New York (Black Horse) Cavalry; was mustered out in March 31, 1862. He again enlisted August 20th, 1862, in Company F. 147th Regiment of New York Infantry, to serve three years but was discharged March 21st, 1863, by reason of disability.

Unable to work, he lived in the woods, fields and marshes for a year or more and with Gray's Manual of Botany studied plants and to a great extent regained his health. In 1866-67 he spent one year in the Medical Department of the University of Michigan. He then settled in Hubbardston and for 22 years conducted a drug and book store, spending much of his time among his beloved plants. On March 4th, 1869, he was married to Catherine T. Holbrook of Oakham, Mass.

During all these years as a merchant he continued his study of the local flora in which he became very proficient, devoting much time also to reading valuable botanical works.

In the spring of 1889, Mr. Wheeler with Professor L. H. Bailey, then Professor of Horticulture at the Agricultural College, two students and the writer, the party spent two weeks in a botanical trip, passing across the state from Harrisville in Alcona county to Frankfort in Benzie county. During his stay in Hubbardston, he had collected a herbarium of over 7,000 plants which later became the property of the Agricultural College. In 1889, he was elected instructor at this College, taking studies enabling him to graduate in 1891 with the degree of B. S., which College granted him the honorary degree of D. Sc. in May 1907. He became assistant Professor, in all spending eleven years before accepting a position in the United States Department of Agriculture where he soon found his place in identifying plants for several departments of the Government in Washington.

While at the Agricultural College, he spent much time in collecting plants for the herbarium in which he was intensely interested. Previously, in company with Erwin F. Smith, they published a Flora of

CHARLES FAY WHEELER.

Michigan in 1881 and later with Dr. W. J. Beal another edition of the Flora was published, in 1904 in the Report of the State Board of Agriculture.

At the college he was active in organizing and sustaining a botanical club and never tired of arousing interest and assisting students in his favorite pursuit. He was well read and with a retentive memory was able to impart much information on a great variety of topics. He had friends everywhere, hosts of them. He was one of the organizers of the State Academy of Science in 1892 and was chairman of the Section in Botany in 1902.

Dr. Wheeler leaves a wife and two daughters, Mrs. Dick J. Crosby of Washington and Mrs. George N. Eastman of California.

DR. W. J. BEAL.

COMPLETE LIST OF PAPERS AND ADDRESSES PRESENTED AT THE SIXTEENTH ANNUAL MEETING OF THE MICHIGAN ACADEMY OF SCIENCE.

1. Address of the President, An Outline of the History of the Great Lakes, Professor Frank Leverett.
2. Report upon the Progress of the Biological Survey of Michigan, Dr. A. G. Ruthven.
3. The Humanistic Content of Biology. Dr. E. R. Downing, Northern Normal School.
4. High School Requirements in Biology. Prof. W. E. Praeger, Kalamazoo College.
5. What Training Should be Required for High School Teachers in Biology. Dr. F. C. Newcombe, Univ. of Michigan.
6. Plant Excretions. Dr. J. B. Dandeno.
7. Studies in Soil Nitrogen. Mr. C. S. Robinson.
8. Seeds New to Michigan Recently Received with Seeds of Clover and Grasses. Dr. W. J. Beal.
9. Sterilizing Seeds. Dr. Richard de Zeeuw.
10. Poultry Husbandry Experimentation. Mr. H. L. Kempster.
11. Changes in Casein in Storage Butter. Mr. C. W. Brown.
12. *The Production of Agglutinins for B. Cholerae Suis in the Blood of Normal and Immune Pigs. Dr. W. Giltner.
13. Notes on Michigan Reptiles and Amphibia, II. A. G. Ruthven.
14. Some New Light on the Development of Reptilia. E. C. Case.
15. Variation in Lymanaea reflexa, Say, from Huron County. H. Burrington Baker.
16. The Crustacea of Michigan. A. S. Pearse.
17. Preliminary Report on the Anatomy of Physa gyrina, Say. H. Burrington Baker.
18. Notes on the Distribution of the Unionidae of North America. Bryant Walker.

*Published as Technical Bulletin 3 of the Michigan Experiment Station.

19. Regeneration in the Nerves of Cambarus. H. M. MacCurdy.
20. A Contribution to the Theory of Binuclearity (lantern slides). R. W. Hegner.
21. The Origin and Meaning of the Second Polar Body. Chas. R. Barr.
22. On Two Abnormalities in the Crayfish. Lucia Harmon.
23. The Rotary Power of Extracts of the Bodies of Snails. Elliot R. Downing.
24. The Formation of Habit at High Speed. O. C. Glaser.
25. Notes on Some of the Rarer Species of Michigan Birds. Walter B. Barrows.
26. Methods of Photographing Birds (lantern slides). R. W. Herger.
27. A Simple Cooling Device for Use with the Microtome. O. C. Glaser.
28. A Word on Double Embryos. O. C. Glaser.
29. The Theory of Mimicry (lantern slides). Jacob Reighard.
30. The University Biological Station at Douglas Lake (lantern slides). Jacob Reighard.
31. A Further Report on the Pearl Organs in Minnows (lantern slides). Norman H. Stewart.
32. The Pearl Organs of American Minnows in their Relation to the Factors of Descent (lantern slides). Jacob Reighard.
33. Some Methods of Studying Vision in Fishes, with Demonstration of Apparatus. Crystal Thompson and Mary Axt.
34. A Remedy For the Black Fly Pest in the Southern Peninsula of Michigan. Cora D. Reeves.
35. Experiments on the Role Played by Odors in Determining the Behavior of Bees. Max Peet.
36. Variation in the Genus of Snakes, Regina. Chas. W. Obee.
37. Mimicry in Tabanus Atratus. S. D. Magers.
38. The Mendelian Law Demonstrated By the Domestic Fowls. S. D. Magers.
39. Another Nectria Associated with Fusarum. (10 min.) J. B. Pollock.
40. Further Observations on the life History of Puccinia malvaceorum. (15 min.) J. B. Dandeno.
41. A Wide-spread Error Concerning the Identity of the Cortinarius collinitus. (10 min.) C. H. Kauffman.
42. Unreported Michigan Fungi for 1909. (5 min.) C. H. Kauffman.
43. The Distribution of Mushrooms at Negaunee, Mich. (10 min.) Rose M. Taylor.
44. Placentation in the Liliaceae. (15 min.). C. E. Temple.
45. Sodium Silicate as a Mounting Medium. (10 min.) J. B. Dandeno.
46. The Prothallia of the Ostrich Fern in their Relation to the Nitrogen Supply. (10 min.) Elizabeth D. Wuist.
47. Some Attempts to Distort the Mitotic Figure in the Root-tips by Means of Magnetic Force. (15 min.) Elliott R Downing.
48. On the Relation of the Impervious Layer to Plant Distribution. (10 min.) Geo. P. Burns.
49. The Development of Plant-Societies in Drained Glacial Ponds. (20 min.) LeRoy H. Harvey.

50. Notes on the Yellow Adders-tongue. (10 min.) O. A. Farwell.

51. Ecological Notes from the Wasatch Mts., near Logan, Utah. (20 min.) Illustrated with Lantern. W. E. Praeger.

52. Forest Successions on Isle Royale, Michigan. (20 min.) Illustrated with lantern. Wm. S. Cooper.

53. The Identity and Inheritance of Certain Teratological Characters, and their Bearing upon Recent Theories. (20 min.) Illustrated with lantern. Henri Hus.

54. Methods Employed in the Production of Graft-hybrids. (5 min.) N. W. Scherer.

55. Experiments for the Production of Graft-hybrids. (5 min.) C. P. Cronk.

56. The Present Status of the Graft-hybrid Question. (10 min.) Henri Hus.

57. The Proposed Medicinal Garden of the University of Michigan. (10 min.) Henri Hus.

58. Some Observations made at Douglas Lake, Mich. (10 min.) Fred A. Loew.

59. Bleached Flour. Frank L. Haley.

60. The Ann Arbor Water Supply. R. S. Buzzell.

61. The Anti-Tuberculosis Crusade in Detroit. V. C. Vaughan, Jr.

62. Infection of Rats with Leishmania Infantum. Paul A. Schule.

63. The Transmission of Infectious Diseases. Guy L. Kiefer.

64. Recent Observations on Rabies. James G. Cumming.

65. The Amount of Caffein in Coffee, Tea and Other Beverages. Miss Pauline Wurster.

66. Parenteral Administration of Proteids. Victor C. Vaughan.

67. A New Filterable Virus. F. G. Novy and W. A. Perkins.

68. The Usefulness of Curves in the Interpretation of Microbial and Biochemical Processes. Otto Rahn.

69. Testing of Bacterial Filters. W. A. Perkins.

70. Some Physical Properties of Diphtheria Toxin and Venom. Dr. Steinhardt. (Read by title).

71. Staphylococcic Infection of a Cow's Udder Treated with a Bacterial Vaccine. Lawrence T. Clark.

72. Existing Continental Glaciers. (30 minutes.) (slides.) W. H. Hobbs.

73. Earthquakes in Michigan. (10 minutes.) W. H. Hobbs.

74. Extinct Mammals of Michigan. (10 minutes.) N. H. Wood.

75. A Filled Lake Valley. (15 minutes.) (slides.) A. E. Parkins.

76. Minor Cities of Michigan. (15 minutes.) M. S. W. Jefferson.

77. Evidences of Secondary Concentration of the Iron Ores of the Iron River District of Michigan (30 minutes.) R. C. Allen.

78. Geographic Units of Upper Peninsula of Michigan (30 minutes.) L. H. Wood.

79. The Contour of the Sylvania Sandrock and of the Anderton Beds in the Detroit River Area of the Cincinnati Anticline (30 minutes.) Thomas Nattress.

80. The Late History of the Lake Superior Region (15 minutes.) Frank Leverett.

81. The Distributions of the Elements (15 minutes.) E. H. Kraus.

82. Soil Striping in Cold, Humid Regions and a Kindred Phenomenon (10 minutes.) W. H. Hobbs.

83. Restoration of Two Permian Animals (15 minutes.) Slides. E. C. Case.

84. *Diabase of the Cobalt Silver District (20 min.) R. E. Hore.

*85. On the Origin of the Huronian Conglomerate of Nipissing, Ontario. (20 min.) R. E. Hore.

SUBJECT: THE INCREASED COST OF LIVING.

I. *The Situation.*

86. Paper by Wilbur O. Hedrick, of Michigan Agricultural College.

II. *Causes and Remedies.*

87. Monetary Conditions—Jas. E. Mitchell, of Alma College.

88. Labor Conditions—Lewis H. Haney, of the University of Michigan.

89. Monopoly and the Tariff—Frank T. Carlton, of Albion College.

90. Other Industrial and Social Conditions—Edw. D. Jones of the University of Michigan.

III. *General Discussion.*

Opened by Edward M. Arnos, of Olivet College, and E. H. Ryder, of Michigan Agricultural College.

SUBJECT: THE TEACHING OF ELEMENTARY ECONOMICS.

91. In the University, Fred M. Taylor, of the University of Michigan.

92. In the College, Charles H. Gurney and Jas. E. Mitchell of Alma College.

SUBJECT: CURRENT ECONOMIC LITERATURE.

93. Reviews and Discussions by Edward M. Arnos, Frank T. Carlton, Lewis H. Haney, and others.

94. Paper: A General Characterization of the Economic Literature of Recent Years, by Lewis H. Haney.

*To appear in the Journal of Geology.

PRESIDENT'S ADDRESS.

OUTLINE OF THE HISTORY OF THE GREAT LAKES.[1]

Frank Leverett.

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INTRODUCTORY STATEMENT.

Michigan is more broadly washed by the waters of the Great Lakes than any other state of the Union, and its commercial interests are greatly enhanced in value because of this situation. There are also climatic advantages which it possesses because of these water bodies. The question of the origin and history of the lakes should, therefore, be of especial interest to the people of Michigan, and particularly to such an assembly of educators and scientific students as is present this even-

[1]Published by permission of the Director of the United States Geological Survey.

ing. The history is so complex that it can only be sketched in outline in the brief time allotted for this address.[1]

It is primarily to glaciation that we owe the presence of these great lake basins, and a sketch of their history naturally includes an outline of the leading events of the Ice Age. Accompanying the glaciation there have been deformations of the earths form that seem attributable in some measure at least to the great ice sheets that covered the land. The region occupied by the Great Lakes appears to have been weighted down and depressed during the height of glaciation, and to have risen somewhat upon the melting of the ice, yet not to its preglacial altitude. These earth movements are thus important factors in the history of the lakes, though it is not improbable that other forces independent of the weighting and disappearance of the ice have been influential in causing the changes of level here displayed.

GREAT ALTITUDE PRECEDING THE ICE AGE.

That the ice age was preceded by higher altitude than the present in eastern North America is shown by the presence of deep valleys, now submerged, in the gulfs and bays along the Atlantic coast.

From the Hudson valley northeastward the deep valleys are filled with the oldest drift of that region. Borings in the Hudson river valley near West Point, made by the New York Water Supply Commission, show that the valley floor at that place is 450 feet or more below sea level. Wells and borings in the vicinity of Boston show a rock floor 200 to 400 feet below sea level and there are similar deeply filled valleys on the coast of Maine. The coast line at that time was some distance farther out than now and much of the area of the Gulf of St. Lawrence was above sea level. The old valley of the St. Lawrence can be traced through the Gulf and out beyond the banks of Newfoundland. The ice did not cover it far below Quebec and it remains unfilled. It is 800 to 1200 feet below sea level, the depth increasing as one passes down the old channel.

The high altitude, which is easily demonstrable on the coast, is more difficult to prove in the interior of North America around the Great Lakes, for the drainage from that region had a long course to the sea, and the lakes are probably near the headwaters of the old drainage lines. It seems entirely probable, however, that the high altitude of eastern North America would have affected the Great Lakes region and given the beds of the present lakes an altitude high enough to have afforded free drainage to the sea.

It is thought that before the glacial period there were no bodies of water where the Great Lakes now stand, but instead broad lowlands bordered by belts of higher land. The condition seems likely to have been about like central and eastern Tennessee and Kentucky and southern Indiana, where the weak rock formations are marked by lowlands, and the more resistant by highlands.

[1] A much more complete discussion of the subject is now in preparation, for a monograph of the United States Geological Survey, by my associate in glacial investigations, Mr. F. B. Taylor.

PREGLACIAL DRAINAGE.

The courses of preglacial drainage from the lowlands are now concealed beneath thick deposits of glacial material and can only be partially outlined. There is as yet uncertainty whether the drainage was chiefly to the Gulf of St. Lawrence or to the Gulf of Mexico. The high altitude which affected the eastern part of the United States may have given the region along the St. Lawrence below Lake Ontario and also that along the Mohawk greater altitude than was presented by the district between the Great Lakes region and the Gulf of Mexico, thus favoring discharge of the Great Lakes region to the south. It seems highly probable that in the remote past there was a divide on the line of the present St. Lawrence below Lake Ontario, where the river now flows among the Thousand Isles, and that from it drainage passed southwestward to the central United States. But whether this divide had been cut through by headwater erosion of the St. Lawrence and part of the southwest flowing drainage had been changed to a northeast flowing system prior to the Ice Age is not known. The bed of Lake Ontario reaches now the lowest altitude of any of the Great Lakes. Whether the preglacial altitude was lower in this basin, or whether this low altitude is due to greater sinking and greater ice erosion there during the Ice Age than occurred in the neighboring basins of Huron and Erie is not yet determined. In the former case it would seem probable that the Ontario basin had a discharge through some buried channel among the Thousand Isles to the Gulf of St. Lawrence and took with it the drainage from the Erie basin if not from the Huron and the Superior and the northern part of the Michigan basin.

The most ambitious effort to restore the preglacial drainage of the Great Lakes region is that of J. W. Spencer, who some 20 years ago presented a map and discussion of the ancient drainage of the Great Lakes region in a British publication.[1] It was based on a study, (1) of the hydrography of the modern lake basins and submerged channels on the coast, (2) results of well borings which have revealed the position of buried valleys, and (3) the uplift which the Great Lakes region has experienced as shown by tilting of old shore lines. He reached the conclusion that the drainage was to the Gulf of St. Lawrence though not fully along the present lines. From the Erie basin the discharge to the Ontario basin was farther west than Niagara river so that it entered the extreme western end of the Ontario basin. He interpreted the Lake Huron basin to have had a direct southeastward drainage through Georgian Bay and past Lake Simcoe into the Ontario basin near Toronto. He outlined a drainage from the south part of the Lake Michigan basin across the southern peninsula of Michigan into Saginaw Bay and Lake Huron. The northern part of the Lake Michigan basin he interpreted to have drained through the Straits of Mackinac and eastward into Georgian Bay to join the old Huron drainage. Spencer's maps and discussion do not include the Lake Superior basin. My own studies of the district south of Lake Superior have brought to light a deep buried channel leading southward from the east end of the basin to the head of Lake Huron some distance west of the present line of discharge through Ste. Marys River.

[1]Quarterly Jour. Geol. Soc'y of London, Vol. XLVI, 1890.

Whether Spencer's interpretation is correct on the main proposition of an eastward drainage to the Gulf of St. Lawrence remains to be determined. It will be necessary to learn how much the level of the old rock beds have been reduced by ice weighting and differential depression and by ice erosion. The beds certainly have been sufficiently lowered to render it impossible to run the glacial drainage to the ocean over a rock floor sloping continually seaward. The amount of erosion and depression seems to decrease southwestward or toward the peripheral portion of the ice sheet. It will not be surprising, therefore, if the proper evaluation of these factors will throw the balance of probabilities in favor of preglacial discharge of much of the Great Lakes region to the Gulf of Mexico.

The data thus far collected in central Michigan favor this interpretation. The borings along the line of the buried channel that runs across Michigan from Saginaw Bay to Lake Michigan indicate, not only a fall in that direction (which is the reverse of the course outlined by Spencer), but also a widening of the channel. Deep borings in western Indiana between the head of Lake Michigan and the Wabash show a lower rock floor than any yet discovered across Illinois and suggest a preglacial drainage to the Wabash and Ohio.

EFFECTS OF GLACIATION IN GREAT LAKES REGION.

The Great Lakes region has been modified by glaciation in various ways, chief among which are (1) drift deposition, (2) glacial erosion, and (3) probably weighting and depression by the ice. On the first of these modifications, drift deposition, there is opportunity for definite knowledge, and no differences of opinion are held by geologists. On the second and third there are debatable questions, and in consequence a lack of uniformity of opinion.

EFFECT OF DRIFT DEPOSITION.

The drift has so completely filled the valleys which connected the several basins that the position of these valleys is known only through data from borings. Their beds lie far below the present surface of the lakes. Consequently were the drift removed from these channels the lakes would stand much lower than at present. The basin of Lake Erie, it should be noted, is rendered shallow by a thick accumulation of drift. The greatest depth of water is about 210 feet, but borings at Cleveland, near the mouth of Cuyahoga River, show the drift to extend down to within 100 feet of sea level, or more than 470 feet below lake level.

The present divide between the Great Lakes or St. Lawrence drainage and the Mississippi drainage is determined very largely by moraines and thick drift deposits. The drift has been heaped up in greatest amount at the ends and along the sides of the tongues of ice that passed over the lowlands now occupied by the Great Lakes. There is also in the southern peninsula of Michigan a remarkable amount of drift, perhaps a thicker deposit than in any other area of equal size in America. This apparently resulted from the convergence of ice movement occasioned by the trend of the bordering Great Lakes basins, there being southward movement on the west side and southwestward on the east. The northern

half of the peninsula, which now rises in places 1,000 to 1,100 feet above the surface of the lakes, seems to have no rock standing more than 250 to 300 feet above the lakes, there being 700 to 800 feet of drift on its higher parts. It has been estimated by W. F. Cooper from planimeter measurements on maps showing present surface and bed rock surface, issued by the U. S. Geological Survey,[1] that the entire southern peninsula of Michigan has an average of about 300 feet of drift. The area of thick drift covers also northwestern Ohio, northern Indiana, and northeastern Illinois, and averages nearly 200 feet.

GLACIAL EROSION.

The large amount of drift deposited at the ends and on the borders of the ice lobes that occupied the basins of the Great Lakes calls for a similar erosion of districts over which the ice passed. Considerable material was gathered in Canada as we know from the occurrence of Canadian bowlders and pebbles in all parts of the Great Lakes region and southward to the glacial boundary. But this appears to be a less important constituent than the material derived from the softer rock formations in and around the Great Lakes basins. The examination of constituents of the drift made in Wisconsin, Illinois, Indiana, Ohio, and Michigan, have shown from 75 to 80 per cent or more of material derived from south of the Canadian boundary.

WEIGHTING AND DEPRESSION BY ICE.

That the region of the Great Lakes has experienced considerable increase in altitude on the withdrawal of the ice sheet is well shown by the tilting of the shore lines of the glacial lakes that were the predecessors of the present Great Lakes. This tilting is so closely connected with the relief of the ice covered district from its burden of ice that it seems highly probable that it came as a result of the relief from this load. As will be shown later it amounts to several hundred feet in the northern part of the Great Lakes region, where the load was heavy, and dies out entirely in the southern part where the load was light. If the unloading has given occasion for such a marked upward movement it would seem a safe assumption that the accumulation of the ice had caused a weighting down or depression from which this is a resilience. The presence of a large amount of drift in the districts bordering the Great Lakes, and especially that in the northern half of the southern peninsula of Michigan, seems likely to have had a measurable effect in preventing complete return to preglacial altitudes. It is perhaps to the great amount of drift east of the northern half of the Lake Michigan basin that the very slight rise of that region is due, a rise so slight that it is scarcely measurable south of Manistee.

It thus appears that the lake basins as we now find them are glacially modified lowlands, which have been loaded in places by drift, and in places eroded and weighted down by the ice. They are held up by rock and drift barriers to levels several hundred feet above their rock beds, the lowest, Ontario, being nearly 250 feet, and the highest, Superior, 600 feet above sea level, while the beds of all except Erie extend in places below sea level.

[1]Water Supply and Irrigation Paper 182, Pl. II.

GLACIAL AND INTERGLACIAL STAGES.

The studies of the glacial deposits have shown that they do not consist of a single sheet but embrace three and in places four distinct drift sheets. There is evidence that these drift sheets are the product of repeated glaciation at widely separated intervals. They are separable by beds of peat and deposits made by lakes and streams. These deposits contain remains of forms of life similar to those now existing in the same regions, and thus they indicate a temperate interglacial climate.

It is probable that after the first glaciation as well as after each succeeding one there were lakes in the basins of the present Great Lakes. These would be invaded and completely filled by ice in each recurring glacial stage. Evidence of such interglacial lakes is largely destroyed by the glacial occupancy and must be at best very fragmentary. Yet there are not wanting features that point to their occurrence. For example, at the southern end of the Lake Michigan basin, and also on the eastern side where dunes now occur, the moraines formed by the last glacial stage are found to be more sandy than their continuation on the western side of the lake basin. This sandiness it is thought may be due to the incorporation of the interglacial dune material in the drift.

The history of the lakes in connection with and subsequent to the last glaciation is so complex that it alone will be outlined at this time. The complexities here outlined are likely to be but a recurrence of those of the interglacial times. The interglacial times differ from the postglacial in that they involve a readvance of ice and extinction of any lakes that may have been present in the basins. The interglacial times were also much longer than the postglacial and there were correspondingly greater filling and modification of the lakes. We are, therefore, presenting in this postglacial lake history a succession of events less complete than probably occurred in each interglacial stage.

In the last or Wisconsin stage of glaciation, and also in the next preceding, or Illinoian stage, the Great Lakes region was covered by ice moving southwestward from a center in Labrador. In a still earlier glacial stage, the Kansan, there appears to have been a southward movement across the Great Lakes region from a center in central Canada known as the Keewatin. At least, copper was distributed from the Lake Superior region as far southeast as central Ohio probably by ice moving southward through the Huron basin and across the western portion of the Erie basin. The lake history is likely to have been different at the withdrawal of the Keewatin ice sheet from the basin it had filled than it was at the withdrawal of the Labrador ice sheet in subsequent stages of glaciation. It would not, however, be an easy matter to unravel that part of the Great Lakes history, for any moraines or features that would throw light on the outline of the ice border have been overridden and completely concealed by the later invasions from the Labrador center.

FEATURES CHARACTERISTIC OF LAKE SHORES.

Inasmuch as the predecessors of the Great Lakes stood at higher levels than the present bodies of water and covered certain outside territory, the features characteristic of lake shores have been discovered in this outside territory and used as a basis for interpreting the

extent of the ancient water bodies. These include bars of gravelly material thrown up by waves along the old shores, and abrupt banks formed where the waves cut back into the bordering land; also deposits with the delta form and structure laid down where streams entered the old lakes. The beaches of a given lake lead into the head of its outlet at a level corresponding to the ordinary stage of water in the outlet. In some cases, however, the outlet experienced considerable deepening during the life of the lake and one finds later beaches opening into it at levels corresponding to this deepening.

THE SUCCESSION OF LAKES.

It is evident that when the ice sheet extended out to or beyond the divide between the Great Lakes and the Mississippi drainage there would be a direct discharge along valleys into the Mississippi and no lakes would be present. But as soon as the ice had shrunk back inside the divide to where the land sloped toward the ice border lakes would begin forming. There would be at first small bodies of water at numerous points along the borders of the basin, either discharging directly across the rim by independent outlets or having connection by border drainage along the ice edge to some low place on the rim of the basin. With the shrinking of the ice the small lakes which at first were independent, or were connected by border drainage channels would become confluent and take the level of the lowest water level of the series.

Inasmuch as the melting of the ice uncovered the southern and southwestern borders of the lake basins earliest, it is here that we find the beginnings of the lakes. These basins extend somewhat farther out than the present Great Lakes, and it is in these extensions that the first ponding occurred; in some cases while the whole area now occupied by water was occupied by the ice.

It is scarcely possible as yet to determine in which basin the ponding of water took place earliest. Mapping of moraines has been carried far enough to indicate that there was no great difference in the dates of the beginning of the lakes in the southwest ends of the Superior, Green Bay, Lake Michigan, and Lake Erie basins, whereas the lakes formed in the Huron and Ontario basins were much later. A lake in the Saginaw basin southwest of Lake Huron was earlier than in the southern end of Lake Huron. The lake in the Ontario basin came in the latest of any in the large basins, being situated farthest northeast and consequently nearest the center of dispersion of the ice.

SUPERIOR BASIN.

The earliest part of the drainage basin of Lake Superior to be vacated by the ice seems to have been in the district now drained by St. Louis River. As noted by Winchell,[1] the ponded waters in the southwest part of this river basin were at one time discharged southwestward to the Mississippi from an altitude about 700 feet above Lake Superior, as indicated in Fig. 1. The name Lake Upham has been given to this small and transient water body. With the shrinking of the ice border a lower passage, about 530 feet above Lake Superior was opened from

[1]Bull. Geol. Soc. Am. Vol. 12, 1901, p. 124.

the St. Louis River to Kettle River and thence to the St. Croix and this drew the water down below the level of the outlet of Lake Upham. To distinguish this lower lake stage in the St. Louis drainage basin it has been named by Winchell Lake St. Louis. A little further shrinking of the ice border exposed the headwaters of Nemadji River, a stream that comes into the head of Lake Superior from the west-southwest, and there was formed a small lake about 500 feet above Lake Superior level, known as Lake Nemadji. It received the melting waters from the end of the Superior lobe and discharged a large volume of water down the Kettle River valley into the St. Croix, though only 30 square miles in

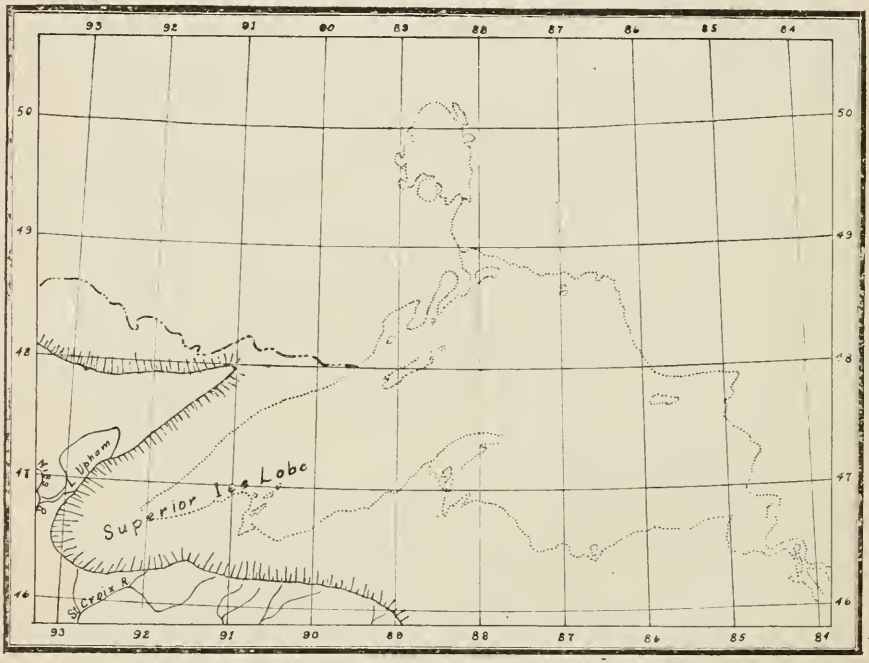


Fig. 1. Superior Ice Lobe and Lake Upham.

area. During the life of each of these lakes the ice sheet still completely covered the area of Lake Superior.

As the ice border shrank within the limits of the western end of Lake Superior a large body of water, named Lake Duluth (Fig. 2), came into existence. Its outlet was southward from the head of Brule River in northwestern Wisconsin into the St. Croix River. While this was still a small lake there was formed another lake farther east called Lake Ontonagon for it covered much of the Ontonagon drainage basin in the western part of the northern peninsula of Michigan. It discharged westward along or near the ice border into Wisconsin where it joined Lake Duluth in the discharge through the St. Croix valley. Its outlet made a descent between 150 and 200 feet, however, before reaching Lake Duluth. With the recession of the ice border Lake On-

tonagon became confluent with Lake Duluth but at a level considerably lower. It consequently vacated much of its bed.

The St. Croix outlet served as the line of discharge for this glacial lake in the western part of the Superior basin until the ice border had receded to the eastern slope of the Keewenaw Peninsula if not beyond it (Fig. 2).

It will be observed that the highest shore of Lake Duluth is not at a uniform level but shows a marked rise toward the northeast. Thus at the western end it is 1,066 feet above sea level or 465 feet above Lake Superior, while at Calumet on the Keewenaw Peninsula it reaches

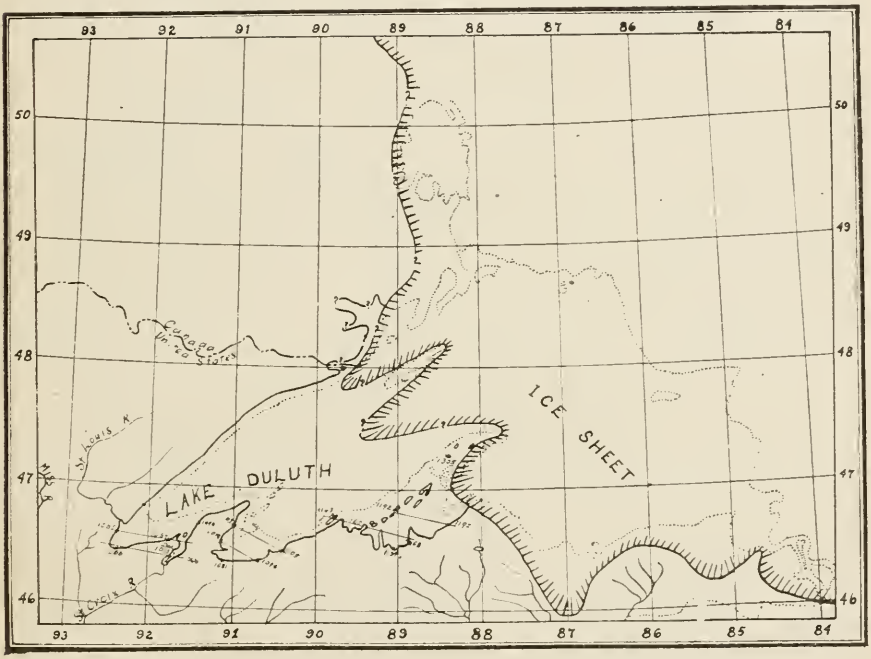


Fig. 2. Lake Duluth at greatest extent, and probable contemporary ice border. Numerals and isobases indicate altitude of the highest beach above sea level.

1,503 feet, or 702 feet above the present lake. This rise of 237 feet seems to be largely attributable to a subsequent differential uplift, though a small portion is perhaps referable to an actual higher position of the lake at the northeast end due to ice attraction. The effect of ice attraction seems unlikely, however, to amount to 37 of the 237 feet and would be mostly within a few miles of the ice border. It will be observed that the lines of equal elevation, or isobases, connecting certain points on opposite sides of the lake, trend south of east but they are not uniform in direction even in the small area covered by definite data. It appears from this that the uplift was not regular. There is need for precise levels along the whole shore to clear up the form of warping or uplift this region has experienced. The direction of tilting,

which for any given line is at a right angle to the isobase, varies on different lines from about 10° to nearly 30° east of north. It appears that the entire basin lies within the region of uplift, for there is a decrease in altitude clear to the southwest end of the lake.

It will be observed that the head of the outlet is only 1,013 feet while the lowest part of the upper shore is 1,066 feet, or a difference of 53 feet. It is scarcely to be supposed that the outlet carried a depth of 50 feet of water at its head. Instead it seems probable that it was deepened 40 to 50 feet after the lake waters were turned into it. In fact the head of the outlet is low enough to afford discharge for the lake after it had dropped to the level of its second beach.

Lake Duluth represents a somewhat long stage in the glacial lake history. Its duration is measurable either in terms of ice recession or of work by the lake and its outlet. The recession of the ice border seems to have been more than 100 miles in the axis of the lobe and perhaps an even greater distance in the region north of Lake Superior. The time involved in such a recession must be expressed in hundreds if not in thousands of years. The work accomplished in the outlet has not been fuly ascertained for studies have been restricted to the immediate head of the outlet. At the head of the outlet there appears to have been a deepening of 40 to 50 feet in a channel nearly a mile in average width cut in sandy drift. The amount of work in this outlet seems to be less than in outlets from glacial lakes in the Michigan and Erie basins. This may be partly because of its briefer duration and partly because of its smaller volume. The beaches of Lake Duluth are strong and easily traced in all situations and indicate long duration as clearly as the outlet channel.

The occurrence of certain beaches in the western Superior basin that are too low to open into the St. Croix outlet and too high to correlate with the highest beach having an eastward outlet, the Algonquin beach, seems to demand an outlet somewhere on the north side of the basin. The ice down to the time of this supposed northward outlet probably covered the region around Lake Nipigon north of Lake Superior. A further recession would have let the waters into the Nipigon basin, and thence perhaps northward and westward into the basin of the great Glacial Lake Agassiz. This region, however, awaits investigation to settle the course or courses of discharge for the waters. With further withdrawal of ice on the southern part of the Lake Superior basin the waters became connected with those in the Lake Michigan and Lake Huron basins to form the great Lake Algonquin, discussed below.

GREEN BAY BASIN.

That there was a glacial lake in the Green Bay basin with an outlet into the Wisconsin River near Portage, Wisconsin, is known from the well defined outlet channel, discussed by Upham in 1903[1] and by the presence of shore features at corresponding altitude at points along the borders of the Green Bay basin (Fig. 3). W. C. Alden of the United States Geological Survey has found a well defined shore east of Lake Winnebago at about 800 feet above sea level, or only 10 to 12

[1]American Geologist, Vol. 32, 1903, pp. 105-115, 330 331.

feet higher than the bed of the outlet, but in parts of the border the shore is very weak and ill defined.[1] The red clay of the Green Bay basin which Upham considered a deposit of the lake bed has been found by Alden to be a glacial deposit. It was on the withdrawal of the ice after depositing the red drift that the lake reached its greatest extent, and it only persisted until the ice had melted far enough back to give an eastward discharge into the Lake Michigan basin.

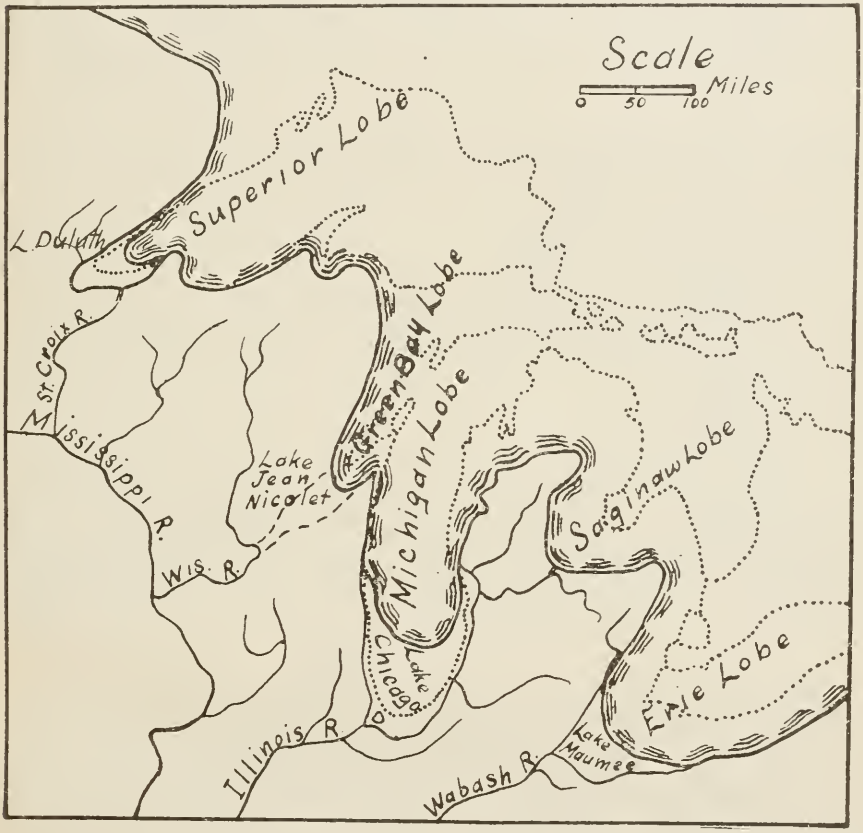


Fig. 3. Beginnings of lakes in Superior, Green Bay, Michigan, and Erie basins, with correlative ice border.

MICHIGAN BASIN.

In the Michigan basin there was at first a chain of lakes along the eastern side of the southern portion and a narrow strip of water at the south and southwest which discharged down the Des Plaines valley. The ice filled the basin at that time a little beyond the limits of the present lake, its border being at Blue Island ridge in Illinois, and at the narrow moraine north of Chesterton, Indiana.

[1]Personal communication.

From this moraine the ice border shrank within the limits of the present lake and the lake became expanded eventually over the greater part of the basin (Fig. 3). It is known as Lake Chicago, and its outlet as the Chicago Outlet. As the outlet stood but little higher than the present lake, the extent beyond the present lake was slight. The highest shore is 55 to 60 feet above lake level, so the bed of the outlet at first was about 50 feet above the lake. There are three distinct beaches differing about 20 feet in altitude, known as the Glenwood, the Calumet, and the Toleston. The highest and oldest marks the level of the lake during the cutting of a trench in the gravel formations along the outlet. The second or Calumet beach marks the level of a rock sill over which the lake outlet flowed for considerable time before cutting it away. The removal of the rock, it has been suggested by Chamberlin, was by a stoping process, there being rapids at first at the down stream end of the rock sill, which by wearing backward gradually narrowed the rock barrier until it finally gave way and let the lake drop to the level of the third or Toleston beach. The Toleston stage persisted until the ice had melted out of the Michigan basin and connection was established with Lake Algonquin in the Huron basin. It is probable, though not yet fully established, that the Chicago Outlet served for a time as the line of discharge for waters in both these basins and also of the Superior basin. But with the opening of the eastern outlet for Lake Algonquin through the recession of the ice in Ontario the lake seems to have been drawn down below the level of the Chicago Outlet. Another rise of water took place at the close of the lake stage known as the Nipissing, discussed below, the water reaching an altitude about 16 feet above the present lake Michigan. The outlet became blocked by sandbars at this stage and the lowering of the lake to the present altitude has been a result of cutting in the St. Clair outlet. The Chicago Outlet is now occupied by the small Des Plaines River, which takes a straggling course across its bed, and in its meanders scarcely touches the banks of its great predecessor.

HURON-ERIE BASIN.

The portion of the Huron basin south of Saginaw Bay lies in a lowland which is continuous with that of the Erie basin across the Canadian Peninsula. This lowland is termed the Huron-Erie basin. There were converging ice currents in the Huron and Erie basins which became confluent and formed what may properly be termed the Huron-Erie ice lobe.

The Huron-Erie basin has had perhaps a more complicated lake history than any other of the Great Lakes basins owing to the opportunity for discharge of water at various points on its border, exposed one after another in the course of the recession of the ice. It also affects more closely the history of the southern portion of Michigan.

Lake Maumee. The first discharge was from several small lakes on the southern border of the Erie basin into the drainage of the Ohio. These eventually became connected by border drainage and led into a lake known as Lake Maumee, at the southwest end of the basin, which discharged past Fort Wayne, Indiana, to the Wabash River, along

what is known as the Fort Wayne Outlet. (Fig. 3.) During and prior to the development of a large moraine, the Defiance, which forms a loop in the Maumee basin southwest of Lake Erie, and is cut through by Maumee River below Defiance, Ohio, the glacial lake Maumee had a small area in southwestern Ohio and northeastern Indiana and a narrow strip in Michigan southwest of Adrian.

As the ice melted back from the Defiance moraine the lake expanded over the low country to the east and became extended northward on the eastern slope of the Thumb of Michigan[1] as far as Imlay. Here it found an outlet across the Thumb and drained past Flint and Durand into the Grand River and thence to Lake Chicago, its course being along the edge of the Saginaw ice lobe nearly to Grand River. (Fig. 4.)

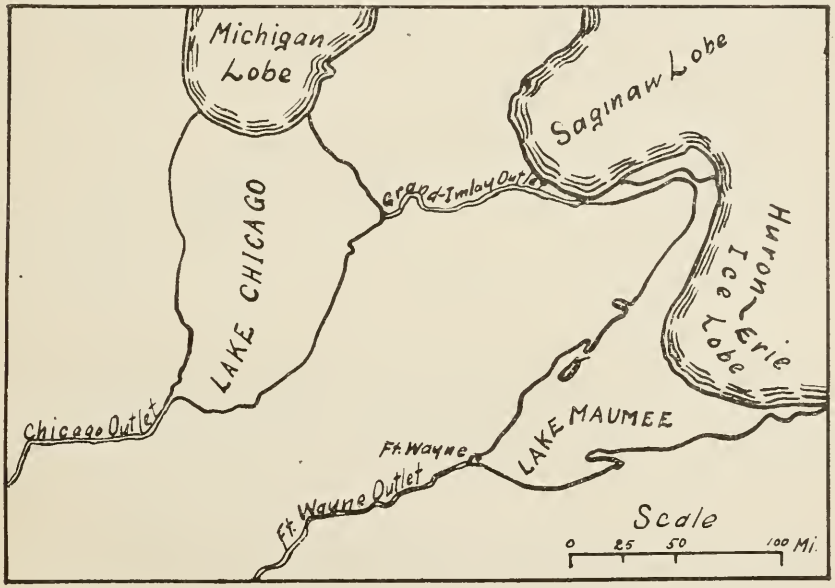


Fig. 4. Lake Maumee and Lake Chicago, with correlative ice border.

At present the bed of the channel at the head of the Imlay Outlet stands 45 to 50 feet higher than the head of the Fort Wayne Outlet largely because of differential uplift of the northern outlet. A comparison of the altitude of the highest beach of Lake Maumee with each of the outlets indicates that the Imlay Outlet probably stood about 15 feet lower than the Fort Wayne Outlet. The summit in its bed is 40 feet below the highest beach, while the summit in the Fort Wayne Outlet is only about 25 feet below the same beach. The second beach of Lake Maumee is barely high enough to have afforded discharge through the Fort Wayne Outlet, but it stands 20 feet above the head of the Imlay Outlet. The actual difference in level of the highest beach at the two outlets is 60 to 65 feet, being 785-790 feet at Fort Wayne and about 850 at

[1]The Thumb of Michigan is the peninsula between Saginaw Bay and the Huron-Erie basin.

the head of the Imlay Outlet. Since the ice border was near by the Imlay Outlet and remote from the Fort Wayne Outlet the water surface may have been drawn up by ice attraction to a slightly higher level at the Imlay Outlet. The amount of ice attraction must be deducted from the 60 to 65 feet to show the actual differential uplift. Another qualifying condition is found in the amount of peaty filling which each outlet contains. The amount appears to be several feet greater in the Imlay Outlet than in the Fort Wayne. It may be sufficient to counterbalance the amount that would need to be subtracted because of ice attraction.

With further recession of the ice border on the Thumb lower outlets were found across it, one near Ubly, and a lower one still farther north, and the Imlay Outlet was abandoned.

Lake Arkona. The lowest of the three outlets across the Thumb is not now exposed to view because the ice readvanced and filled it. This readvance raised the lake waters to the level of the next higher or Ubly Outlet. The beaches of the lake formed at this lower stage are, however, preserved at certain places just outside the moraine of readvance at lower levels than the beach that opens into the Ubly Outlet. The name Lake Arkona is applied to this water body that preceded the advance of the ice, and the features of this lake have been discussed by Taylor in an earlier report of the Michigan Academy.[1] Its full limits on the north are not known, but it is supposed to have extended over much of the Saginaw basin as well as the district east of the Thumb. It appears also to have extended eastward into New York beyond Buffalo to the vicinity of Alden where its beaches are preserved in a protected situation back of a moraine, thus duplicating the features noted on the Thumb.

Lake Whittlesey. The stage of the lake that accompanied the readvance of the ice and utilized the Ubly Outlet has been named Lake Whittlesey. Its beach is the best defined of the whole series in the Huron-Erie basin, and was traced through much of southern Michigan some 70 years ago by Bela Hubbard. It was used as a highway or ridge road in the earliest days of settlement and still continues in use extensively. It is conspicuous as far north as the latitude of Port Huron on the east slope of the Thumb from St. Clair county to Lenawee and thence continues around the western and southern sides of Lake Erie into western New York. (Fig. 5.) Its eastern terminus in New York as well as its northern terminus in Michigan is found at a moraine that marks the contemporary ice border.

The Ubly Outlet discharged to a small lake in the portion of the Saginaw basin southwest of Saginaw Bay and thence through the Grand River outlet to Lake Chicago.

The beach of Lake Whittlesey is horizontal from near Birmingham, a few miles north of Detroit, around the western and southern sides of Lake Erie to the vicinity of Ashtabula, Ohio, but north from Birmingham and east from Astabula it shows a marked rise resulting from differential uplift. At the Ubly Outlet its altitude is about 60 feet higher than in the horizontal portion, and in western New York it reaches an altitude about 150 feet above the horizontal portion.

Lake Warren. With the recession of the ice border from the northern

[1]Seventh Report, 1903, pp. 29-36.

part of the Thumb, Lake Whittlesey abandoned the Ubly Outlet, and the waters in the Huron-Erie basin became confluent with those in the Saginaw. The lake extended so far outside the limits of the Saginaw basin that it has seemed inappropriate to call it Lake Saginaw, and the name Lake Warren has been applied. Its eastern end was in the

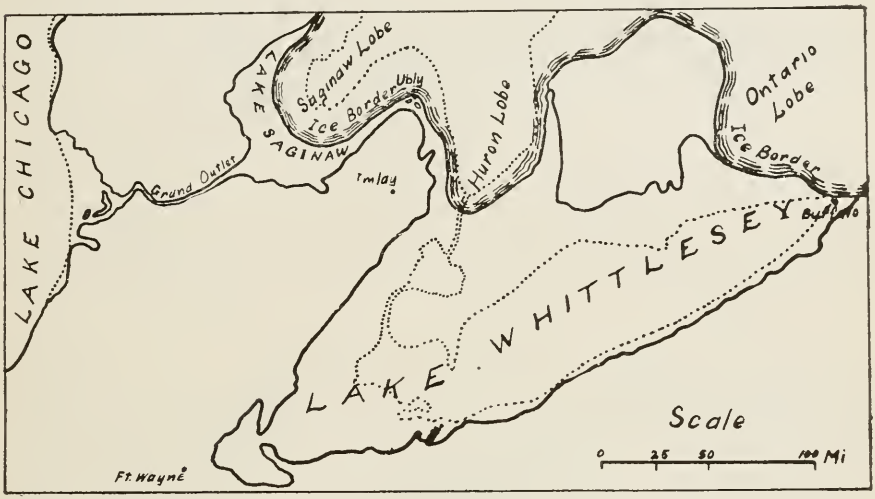


Fig. 5. Lake Whittlesey, with correlative ice border.

Finger Lake region of central New York, and it covered a large area on all sides of Lake Erie (Fig. 6). During its existence the ice was still present in the Ontario basin and prevented eastward discharge. The outlet was westward through Grand River to Lake Chicago. The water level was sufficiently high to submerge the site of Niagara Falls to a depth of about 250 feet.

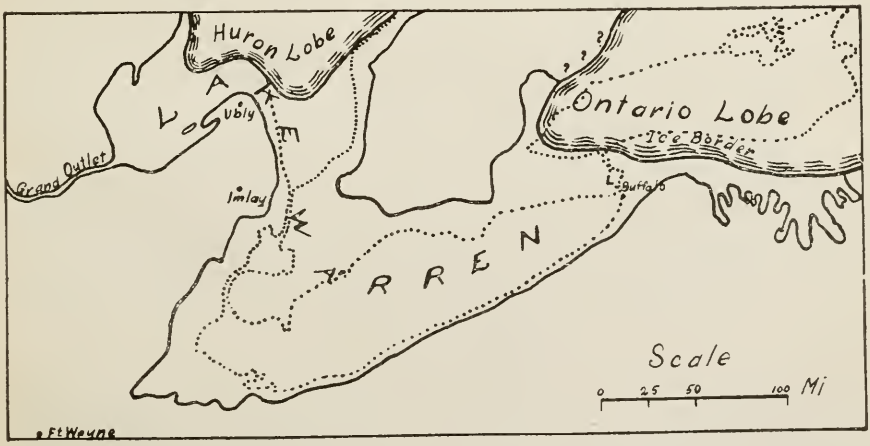


Fig. 6. Lake Warren, with probable correlative ice border.

The lake has two well defined beaches differing about 20 feet in level. These beaches have suffered differential uplift in the Saginaw basin and on the northern part of the east slope of the Thumb, and also in the eastern part of the Lake Erie basin, but elsewhere they are horizontal. In the horizontal portion the higher beach stands about 680 feet above sea level or 100 feet above Lakes Huron and Michigan and the lower one about 660 feet above sea level. In western New York the higher beach reaches an elevation of 880 feet, or 200 feet above the horizontal portion.

Transitional lakes. (*Grassmere and Elkton beaches*). As the ice border shrank into the Ontario basin passages were opened for the dis-

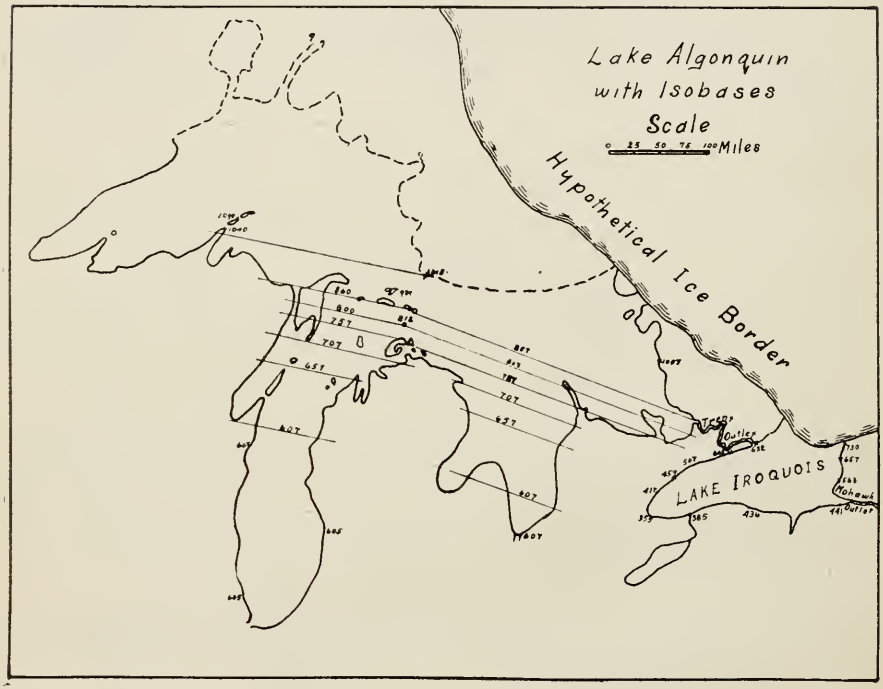


Fig. 7. Lake Algonquin and Lake Iroquois, with probable correlative ice border. Numerals and isobases indicate altitude above sea level of the highest beach of these lakes. Isobases of Michigan and Huron basins by Taylor and Goldthwaite.

charge of the waters of Lake Warren eastward past Syracuse, New York, to the Mohawk valley, at altitudes low enough to draw down the lake level and cause the abandonment of the Grand River Outlet. The ultimate discharge by the new route was to the Atlantic Ocean at New York instead of to the Gulf of Mexico. Two weak beaches were formed in southeastern Michigan, known as the Grassmere and the Elkton, at levels 20 and 40 feet respectively below the level of the lower of the two beaches of Lake Warren. While full tracing has not yet been made around the entire course from Michigan to New York it seems probable that these beaches are to be correlated with two of the eastern outlets, past Syracuse.

The lowering of this eastward discharge was not at first sufficient to uncover Niagara River, but eventually the ice border shrank within the Ontario basin sufficiently to allow discharge over a low col at Rome, New York, the lake was drawn down to a level more than 150 feet below that of the crest of Niagara Falls, and the cataract came into operation.

Lake Erie. Inasmuch as the eastern part of the Erie basin has suffered considerable differential uplift subsequent to the draining of Lake Warren, the beginning of Lake Erie was as a small body of water in the eastern end of its basin, which has been extended westward with the raising of the outlet (Fig. 7). Evidence that it did not formerly cover the western part of its area is found in the submerged lower courses of the streams in the western part of the basin, especially that of Sandusky River, which has been traced by Mosely entirely across the bed of Sandusky Bay. Evidence of a rise of water is also found in submerged stalactites in the caves on Put in Bay Island in the western part of the lake.

ONTARIO BASIN.

Lake Iroquois. The lake in the Ontario basin known as Lake Iroquois (Fig. 7) began as a narrow strip of water along the front of the ice at the south side of the Ontario basin and became gradually expanded over the entire width of the basin as the ice sheet melted back. The discharge was continued through the Mohawk valley during this recession for the ice sheet completely blocked any passage down the St. Lawrence. The level of Lake Iroquois was, throughout, considerably higher than the present surface of Lake Ontario. Its beaches have suffered differential uplift and are much higher in the northeastern portion of its basin than in the southwestern. Inasmuch as the outlet is at the side of the basin, the effect of the uplift has been to raise the waters on the portion of the shore south of an isobase running through the outlet and to cause the water to recede from the portion of the shore north of the isobase. The highest beaches of the northern part of the basin can not be traced into the southern part of the basin for the rise of water in that part of the basin has effaced them almost completely. The single beach present in the southern part of the basin is, therefore, a correlative or continuation of the lowest Iroquois beach of the northern part of the basin.

Champlain Sea. When the ice had opened a passage northeast of the Ontario basin the altitude was so low that the sea came into the basin (Fig. 8) and stood at a level slightly higher in the northeastern portion of the basin than the present shore of Lake Ontario, but in the remainder of the basin the old sea level shore passes beneath the waters of Lake Ontario. The differential uplift subsequent to this invasion of the sea has given Lake Ontario its present extent and level.

LAKE ALGONQUIN.

The lake history thus far has required a separate discussion for each of the lake basins but it is now possible to consider a lake stage that involves the basins of the three upper lakes, Superior, Michigan, and Huron, for upon the extinction of Lake Warren and the withdrawal

of the ice from the vicinity of the Straits of Mackinac and the Ste. Marys River, a single large lake, known as Lake Algonquin (Fig. 7), occupied the basins of the present Lakes Superior, Michigan, and Huron, and part of the intervening territory. Sometime during the life of Lake Iroquois the ice uncovered the Trent valley in Ontario and gave an outlet for the waters of Lake Algonquin into this lake in the Ontario basin. Prior to this the discharge had been either through the Chicago Outlet or the St. Clair Outlet, or perhaps through both of these outlets. The change to the Trent Outlet appears to have been due to lower altitude along that line than either of the other out-

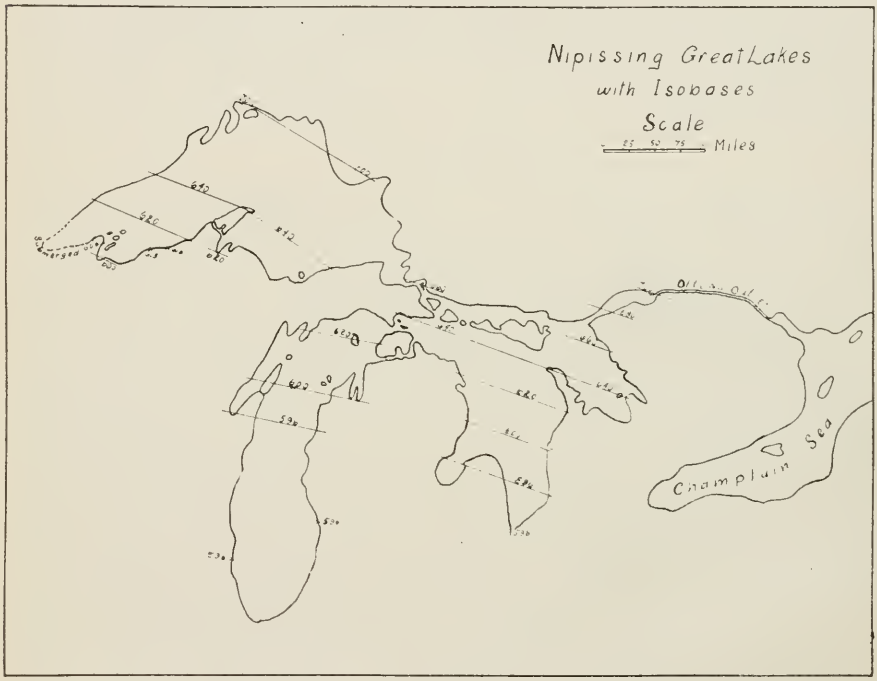


Fig. 8. Nipissing Great Lakes and Champlain Sea. Numerals and isobases give altitude above sea level of the highest exposed shore. Isobases of Michigan and Huron basins by Taylor and Goldthwaite.

lets possessed. Uplift in the region bordering the Trent outlet, however, eventually brought the lake up to a level high enough to resume discharge through one or both of the former outlets, and to cause the abandonment of the Trent outlet. The altitude of Lake Algonquin when brought up to a redischarge through the southern outlet or outlets was about 25 feet above the level of Lakes Huron and Michigan, its beach at the southern end of Lake Huron being 605 to 607 feet above sea level. In the Lake Michigan basin it came back to the level of the third beach of Lake Chicago which is 20 to 25 feet above Lake Michigan.

The conditions on the north side of Lake Superior have not been

determined sufficiently to afford data as to the area of the lake or the height of its beaches. Professor Coleman has noted shore features on the northeast border of the Lake Superior basin up to an altitude of about 1,400 feet above the sea or 800 feet above Lake Superior which are thought to represent the work of Lake Algonquin.[1]

The area of Lake Algonquin has suffered differential uplift throughout the Superior basin and much of the Huron basin, but uplift has affected only the northern portion of the Michigan basin, as may be seen by reference to Fig. 7. In the southern portion of the Huron basin, and as far north in the Michigan basin as the mouth of Grand Traverse Bay, and the north end of Door peninsula in Wisconsin, the amount of uplift has been but a few feet, and the slope of the beaches is therefore very gradual, with scarcely any splitting into separate members. Farther north, however, the rate of uplift is much more rapid, and the beaches are found to split up into several members. The splitting of the beaches shows clearly that the uplift was in progress during the life of Lake Algonquin. The divergence of the several members of the Algonquin shore amounts to more than the uplift which has taken place since the lowest of the beaches was formed. It thus appears that the resilience was very rapid in the course of the departure of the ice, though there was not a complete restoration of the preglacial level, and a slow rate of uplift is apparently going on at the present day.

It is a matter of interest to note the area affected by uplift during the Lake Algonquin stage does not extend so far south in the Huron-Erie basin as that which affected the shores of Lake Whittlesey and Lake Maumee, but the cause for the lessening of the area of uplift is not as yet fully established. The features suggest a complete resilience in the southern portion of the uplifted area very soon after the recession of the ice from that area; whereas farther north complete resilience has not as yet been attained.

It will be noted that the trend of the isobases of Lake Algonquin is not uniform through all the area of uplift (Fig. 7), the trend being more nearly east to west in the Michigan basin than in the Huron and Superior basins. If we may judge by the isobases of Lake Duluth in the western Superior basin (Fig. 2), the trend of the isobases is not uniform throughout the width of that basin. The tilt lines in different parts of the Lake Algonquin region, or lines at a right angle to the isobases, have a tendency to trend in the direction of the axial movement of the ice in each of the great basins, the movement in the Michigan basin being more nearly southward than in the Superior and Huron basins. This may signify that the variations in the trend of the tilt line have been governed to some extent by the lines of heaviest ice weighting.

TRANSITION LAKES (BATTLEFIELD AND FORT BRADY BEACHES).

The Algonquin Lake stage was brought to an end by the opening of an eastward passage along the ice border into the Ottawa valley, just as Lake Warren was brought to an end by the opening of a passage along the ice border into the Mohawk valley. The Ottawa valley is several miles in width, and the ice border appears to have shrunk across it from

[1]Eighteenth Annual Report, Bureau of Mines, Ontario, 1909, pp. 286-87.

south to north so that the earliest discharge was along the face of the south bluff. It is probable also that after the main valley had been uncovered ice lobes protruded into it from northern tributaries and blocked it up sufficiently to hold the waters considerably above the level of the valley bottom. Features pointing to such a history are found in the occurrence of weak shore lines in the Huron, Michigan and Superior basins at levels too low to be included in the Algonquin beaches and too high for the Nipissing shore. There are two such shore lines, the higher of which is known as the Battlefield beach, because well developed on the battle grounds on Mackinac Island, while the lower is termed the Fort Brady beach, it being well developed at Fort Brady near Sault Ste. Marie.

NIPISSING GREAT LAKES.

The Nipissing Great Lakes began with the complete lowering of the lake waters to the level of the low pass that leads from Georgian Bay eastward past Lake Nipissing into the Ottawa valley (Fig. 8). The present small lake east of Georgian Bay, known as Lake Nipissing, lies near the head of the old outlet. The term Nipissing Great Lakes is applied because of the close association of the Nipissing shore at its latest stage with the shore of the modern lakes in the Michigan, Huron, and Superior basins.

At the outlet by Georgian Bay and in the extreme northeast part of the Superior basin uplift has been sufficient to give the beach an altitude about 120 feet above the modern lakes. It falls to only 15 feet above the lake at the southern end of Lakes Huron and Michigan and drops slightly below the level of Lake Superior in the western portion of its basin.

At the time the Nipissing Great Lakes began eastward discharge, the altitude of the outlet appears to have been considerably lower than that of the Chicago or St. Clair outlet, and the lake was drawn down to a somewhat smaller area than the present area of Lakes Michigan and Huron. As the uplift of the outlet progressed the lake became extended with the rise of the waters until it resumed an outflow through the St. Clair River. The beach known as the Nipissing beach, on the borders of the Huron and Michigan basins, and also of the portion of the Superior basin south of an isobase running through the outlet, was formed after the lake had become expanded sufficiently to have a discharge through the St. Clair as well as the Ottawa outlet. It is, therefore, the beach of a two outlet stage. The part of the Nipissing shore north of an isobase running through the head of the Ottawa outlet exposes a series of beaches formed prior to the two outlet stage, as well as the beach of that stage. The continuation of these earlier beaches is submerged in the portion of the lake area south of the isobase running through the head of the outlet.

The direction of tilting of the Nipissing shores does not coincide precisely with the tilt lines of the Algonquin shores, being in places a few degrees to the east. The amount of uplift is very much less than that affecting the Algonquin beaches. The horizontal portion of the Nipissing beach extends over about the same area as that of the horizontal portion of the Algonquin and includes the southern

portion of Saginaw Bay and Lake Huron and fully two-thirds of the basin of Lake Michigan. The tilting affects the entire area of the Superior basin. There has been about 100 feet of uplift at the head of the Ottawa outlet since it was abandoned. The abandonment of this outlet marks the beginning of the modern Great Lakes. The shore of Lake Nipissing formed at the two outlet stage just preceding the abandonment of the Ottawa Outlet is everywhere a strong feature, and indicates that the duration of this stage was comparatively long. It would seem to require a length of some centuries if not some thousands of years. Its duration was such as to suggest a lessening if not a cessation of the differential uplift that led to the rising of the lake to the two outlet stage.

THE MODERN GREAT LAKES.

In view of the changes which have been experienced by the bodies of water in the Great Lakes basins as just outlined, it becomes a matter of interest to determine whether the present Great Lakes will undergo important changes in the future. There are of course processes at work on the shores of all lakes which tend toward the filling and extinction of the water bodies. Material is brought in by streams and the deltas are extended out into the lakes, while the fine material is carried on to settle over the deeper portions of the beds. The material which is cut by waves along the shores is also deposited in the deeper parts of the basins as well as on the borders of the lakes. In the course of many thousands of years, therefore, the lakes would become filled by these ordinary processes. There will also be more or less lowering of the outlets of the lakes by erosion. In this way the level of Lakes Michigan and Huron has already been lowered about 15 feet by the cutting down of the St. Clair Outlet at the south end of Lake Huron. Should the recession of Niagara Falls continue until Lake Erie is reached, the barrier over which the water from Lake Erie now discharges would be removed and the level of the lake correspondingly lowered. In opposition to the processes of erosion comes that of differential uplift and this appears to be affecting the outlets of some of the lakes and it may cause considerable shifting of the lines of discharge.

Observations on the changes in level in the Great Lakes basins undertaken by Gilbert, indicates that a tilting is still in progress, and that the direction of the tilting is about the same as that in the Nipissing shores, or in a general north-northeast direction. The portion of the Michigan basin south of an isobase running east-southeast through the head of the St. Clair outlet is apparently undergoing an extension of the lake, but the Huron basin and the portion of the Michigan basin north of this isobase show a shrinking of the lake from the present shore. The portion of Lake Superior south of an isobase running from the outlet west-northwest and striking the north shore near the line of the United States and Canada is undergoing a rise of water on the shore, while that north of the line is shrinking from the shore. This shrinking has exposed a beach known as the Sault beach which is submerged along the south shore. In the Lake Erie basin, and also in the Lake Ontario, there is an expanding of the entire shore line because the outlets are at the end where uplift is most rapid. In the course of time the uplift

of the outlet of Lake Erie may be sufficient to bring that body of water up to the level of Lakes Michigan and Huron, for it now lacks only 7 or 8 feet of being as high as this higher water body. The continuation of the uplift would bring the water at Chicago to a level high enough to produce a reoccupancy of the Chicago Outlet as a line of discharge. There might then be a two outlet stage such as occurred in the case of Lake Nipissing, one outlet being as at present over Niagara Falls, and the other southwestward along the old Chicago Outlet. A further continuation of the uplift might result in the abandonment of the Niagara Outlet.

The estimated rate of uplift, as determined by Gilbert, is only .42 of a foot in 100 miles in a century, or somewhat less than 2 feet in 100 years at the opposite extremities of the Georgian Bay-Lake Michigan body of water. The contingencies above mentioned, if uplift continues at the present slow rate, lie many centuries in the future, and there is a possibility that the uplift may die out entirely before the lake reaches a stage high enough to transfer the discharge from Niagara to Chicago.

HISTORY SHOWN BY NIAGARA FALLS.

The several changes of volume in the discharge from the Lake Erie basin over the falls of Niagara are found to be clearly represented in the bed of the gorge below the falls. During the time when only Lake Erie was discharging over the falls, and Lake Algonquin had its discharge through the Trent Outlet, the bed of the gorge was excavated to a shallow depth, but when the large discharge of Lake Algonquin was united to that of Lake Erie a deeper excavation occurred in the vicinity of the whirlpool. Then when the Nipissing Great Lakes had eastward discharge and left only Lake Erie to discharge over the falls a shallow portion of the bed of the gorge between the whirlpool and the suspension bridge marks the work done by the small Lake Erie Outlet. With the return of the waters that came about in the change from the Nipissing Great Lakes to the modern Great Lakes a deep excavation of the bed of the gorge set in which continues to the base of the present Horseshoe Fall.

The rate of recession of Niagara Falls has been a subject of careful investigation in order to form a basis for an estimate of the length of time involved in the entire recession of the cataract. The American Fall, which carries only a small amount of water probably illustrates conditions which obtained during the times of small discharge, while the Horseshoe Fall shows a recession by which the measurement of the time involved in the discharge of the great volume of water can be made. By means of these studies of the recession of the present falls it is estimated that the time can not be less than 15,000 years and it may be as great as 30,000 years since the cataract came into operation, that is, when Lake Warren had given place to Lake Erie. From this it appears that the time involved in the entire lake history from the beginning of Lake Chicago and Lake Maumee down to the present can not well be less than 20,000 to 25,000 years on the basis of the lesser estimate of 15,000 years for the recession of Niagara, and it would considerably exceed 30,000 years on the basis of the larger estimate. This

places the culmination of the last stage of glaciation back some 50,000 years or more. These figures, while merely approximate, serve to indicate in a rude way the order of magnitude of the time involved in the changes shown in the history of the Great Lakes.

BIBLIOGRAPHICAL NOTES.

Space will not permit a complete bibliography of the Great Lakes Region for there are several hundred titles. A few notes, however, will be presented which may serve to put those interested in the subject on the track of the literature.

A fairly complete bibliography of North American Geology is given in Bulletins 127, 188, 189, 301, 372, and 409 of the United States Geological Survey. These Bulletins are so arranged that it is possible to find many titles under the name of the State or Province, or under certain subjects (as Pleistocene), as well as under an author's name.

A few students have given especial attention to the features of the Great Lakes, among whom should be mentioned F. B. Taylor, J. W. Spencer, H. L. Fairchild, G. K. Gilbert, Warren Upham, A. C. Lawson, W. C. Alden, E. L. Moseley, J. W. Goldthwaite and the present writer. Many others have given incidental attention to lake features in connection with other investigation. This is the case with persons who have prepared county reports of Ohio, Michigan, Indiana, Illinois, and Minnesota, and district reports in New York, Wisconsin and Ontario. Contributions of this sort have been made by Charles Whittlesey, M. C. Read, A. A. Wright, J. S. Newberry, N. H. Winchell, and G. K. Gilbert, in the Ohio geology; by W. H. Sherzer, A. C. Lane, W. F. Cooper, W. M. Gregory, and I. C. Russell, in the Michigan reports; by W. S. Blatchley and C. R. Dryer in Indiana reports, and by H. M. Bannister in Illinois reports. The old beaches of the western shore of Lake Michigan have been discussed by Goldthwaite in Bulletins of the Illinois and Wisconsin surveys. Early descriptions of the beaches of eastern Wisconsin were made by Chamberlin in the Geology of Wisconsin. The beaches of the portion of New York bordering the Erie and Ontario basins have been made a subject of special investigation by Fairchild and have received incidental attention from several other geologists. The beaches in Ontario have been studied extensively by J. W. Spencer and also by Taylor and Goldthwaite, and have received incidental attention of Chalmers, Coleman and other members of the Canadian Survey.

The ancient shores of the Great Lakes attracted the attention of travellers and explorers in the early part of the 19th century, mention of such features being made by J. J. Bigsby in 1821, by DeWitt Clinton in 1824, and by Featherstonehaugh in 1831. The beaches on the borders of the Lake Superior basin attracted the attention of the members of the Land Survey and are mapped in many places in districts covered by W. A Burt and Douglas Houghton. Members of the First Geological Survey of Michigan, notably Bela Hubbard, and C. C. Douglas, gave attention in 1838 to 1840 to the ancient beaches of southeastern Michigan and in the vicinity of the Straits of Mackinac; while the old beaches south of Lake Superior received the attention of Agassiz and Desor about 1850. In Schoolcraft's Narrative Journal of Travels

in 1820 the shore features of Lake St. Clair, the west side of Lake Huron, both sides of Lake Michigan, and part of the south shore of Lake Superior, are described with considerable accuracy. The narrative also reviews the explorations by Marquette, Joliet, LaSalle, Hennepin, La-Hontan, and Charlevoix in the Great Lakes region.

Ann Arbor, April 1910.

ON THE GLACIAL ORIGIN OF HURONIAN ROCKS OF NIPISSING, ONTARIO.

REGINALD E. HORE.

In the early (1846 et seq.) reports of the Canadian Geological Survey there appear descriptions by Sir Wm. Logan of a series of non-fossiliferous clastic rocks found on the west shore of Lake Temiskaming and north of Lake Huron. Logan correlated the rocks of the two localities and gave them the name Huronian. He believed them to be younger than, and made up partly of detritus from, the Laurentian, and his conclusions have been verified by later observers.

Recently these rocks have attracted more than local interest on account of the discovery of rich silver veins at Cobalt. In six years this camp has yielded sixty-three million ounces of silver at a net profit of seventeen million dollars, and it is expected that the production of the coming year will be greater than that of any previous.

As a result of their economic importance the rocks have been subject to much closer examination than before, and many interesting features have been noted. Among these are peculiar characters which are strongly suggestive of the existence of glaciers in Nipissing in early Huronian times.

Dr. A. P. Coleman[1] who has made a study of these rocks from the stand point of the glacialist, has gathered evidence from which he concludes that there is no doubt of the glacial origin of the basal conglomerate of the lower Huronian.

It is purposed here to present some facts which bear on this question.

As will appear from the accompanying table the chief rocks in this district are of the Archean and Algonkian groups. These are separated by a very marked unconformity and the interval was doubtless the greatest which occurred in Pre Cambrian times. There is no good reason to doubt that for a long period of time the Archean rocks were being worn down by all or any of the erosive agents now active.

The Huronian series doubtless represent a portion of the secondary rocks thus formed, and they are entirely composed of detrital material. They are conveniently grouped into an upper and a lower series which are generally conformable but in some localities separated by a slight unconformity.

The upper series is made up largely of medium grained feldspathic quartzite with a little conglomerate material. It presents no unusual feature and doubtless represents the hardened accumulation of a feldspathic sand derived from siliceous holocrystalline igneous rocks of the Laurentian group.

The lower series is made up largely of conglomerate, shale, greywacke, and feldspathic quartzite. In many cases there is gradual gradation vertically from one of these types to another. Less often there

[1]The Lower Huronian Ice Age, Jour. Geol., Vol. XVI, 1908, pp. 149-158.

is a sharp division line. The composition of one stratum is often fairly constant for some distance; but in some cases a distinct change takes place in a few feet laterally as well as vertically.

ROCKS OF THE NIPISSING SILVER FIELDS.

I. Cenozoic	*Recent*	Clay, marl, peat.
	Pleistocene	(1). Coarse unstratified material—sand, gravel, bowlders; (2). Stratified clay with some sand.
	Great unconformity:	
II. Palaeozoic	*Silurian*	Grey limestone with some interbedded greenish shales, and at the base an arenaceous conglomerate. Correlated with Niagara of New York State.
	Great unconformity:	
III. Algonkian	*Keweenawan*	Igneous intrusives only. Chiefly quartz diabase and quartz gabbro with acid differentiation products. Some olivine diabase and diabase porphyrite dykes.
	Igneous contact:	
	Huronian	Sedimentary rocks only. (a) An upper series. Probably equivalent to Middle Huronian of Lake Superior district. Chiefly feldspathic quartzite with some conglomerate.
	Slight unconformity:	(b) A lower series. Probably equivalent to Lower Huronian of Lake Superior district. Chiefly greywacke, shale, conglomerate, and feldspathic quartzite. The conglomerate pebbles are mostly of holocrystalline igneous rocks, the matrix greywacke and grey shale. The rocks are seldom schistose except as the result of contact metamorphism.
	Great unconformity:	
IV. Archean	*Laurentian*	Igneous intrusives only. Holocrystalline light colored siliceous rocks. Chiefly granites, diorite, syenites and gneisses.
	Igneous contact:	
	Keewatin	Igneous and sedimentary rocks. All much metamorphosed, many being chlorite, hornblende and sericite schists. The relative age of the igneous and sedimentary rocks is doubtful The agglomerates were probably contemporaneous with some of the non-clastic volcanic rocks, and may be contemporaneous with the other sediments. The igneous rocks are chiefly of *extrusive* types.
	Extrusives	(1) Dark colored basic rocks—basalts—mostly with composition and texture of altered diabases. (2) Light colored siliceous rocks—felsite porphyries—mostly quartz porphyries which have been altered to sericite schists.
	Intrusives	(1) Basic rocks, mostly diabase and gabbro. (2) Siliceous rocks, mostly quartz porphyries and porphyrites.
	Sediments	(1) The iron formation, chert, jasplite, carbonates, slates and green schists. (2) Fragmental volcanic rocks—a grey felsite agglomerate.

The shales are for the most part of grey color, less often greenish black. Occasionally they are interbanded with layers of purple, green, and pale gray colors. The chief recognizable minerals are quartz and altered feldspars, minute scales of chlorite and sericite, and small grains of epidote, titanite and iron ores. In mineralogical and chemical composition they are not unlike green shales of other formations.

The quartzites are in most instances feldspathic and grade insensibly into typical arkoses. They are usually very massive, fine to medium grained and not unlike light colored granite in appearance. It is often very difficult to determine their structure, as they are seldom well marked bedding planes. There are however instances in which the

bedding is indicated by variations in the size and relative proportions of the various grains and other cases in which it is indicated by horizontal jointing. The rock is very largely composed of quartz and feldspar. Sericite and kaolin are prominent in light colored varieties and chlorite in the darker. Titanite and iron ores are usually present in small quantity. The feldspar and quartz grains are often well rounded but quite as frequently angular or subangular.

Closely allied to the shales and arkoses are the greywackes. The chief recognizable constituents in these are feldspar, quartz, a dark chlorite and a pale colored mica. Less abundant are small particles of iron ore and epidote, while pyroxene and amphibole are rare. With the minerals are angular and rounded rock particles of various sizes. Rock of this type in some instances is found in massive beds of uniform character, very fine grained and of grey to greenish color. Similar material forms the matrix of much of the boulder conglomerate.

The conglomerate is remarkable for its heterogeneous appearance. Not only are the boulders of a great variety of types but in many cases they show no evidence of arrangement according to size. Frequently one finds boulders a foot in diameter scattered irregularly and sparsely through an aphanitic matrix of shale or greywacke, thus simulating glacial deposits. In other cases there are thick beds of shale quite free from such erratics. There are also beds of boulders of nearly equal size packed close together and with but little of fine grained matrix, as in an ordinary water accumulation of coarse gravel. In some instances the aphanitic beds are distinctly laminated as in ordinary water lain clay, while again similar material forms a compact rock lacking in well developed bedding planes.

As a general rule the large boulders are well rounded or subangular; but there are occasional streaks containing markedly angular fragments. Dr. Coleman found some boulders at Cobalt which show striae and concave surfaces.

The matrix of the conglomerate, which is often greywacke and less often shale, contains numerous angular particles of quartz, feldspar, chert, and felsites. Particles of such shape are very characteristic of, though they are by no means found only in, glacial debris.

Where the contact of the conglomerate with underlying rocks has been found there is a noteworthy lack of alteration in the older rocks. If they were deeply disintegrated by surface weathering the material must have been removed by a very efficient agent. This again suggests ice action. In a few of the contacts the line of demarcation is less distinct, as is ordinarily the case with unconformities in water lain sediments. Naturally the contacts of the latter type are not so likely to be found as those of the former.

There has not yet been found a smooth or striated floor. The basal conglomerate, in some cases at least, has been formed in situ and is made up of detritus from the immediately adjacent rocks.

Prof. Coleman does not consider that the lack of discovery of a characteristic glacial floor precludes the possibility of the material having been placed by ice, and refers to well known instances in which such a floor is lacking.

The localities specially mentioned by Dr. Coleman are Cobalt and

Temagami. Cobalt Lake, on which the town is situated, lies almost entirely in Huronian conglomerate. The conglomerate in turn lies in a deeper valley formed by rocks of the Keewatin group. It might be expected therefore that the coarser material in the conglomerates would be largely detritus from those old greenstones and cherts; but such is by no means the case. The basal portion is made up very largely of material similar to that which enclosed the old valley; but the greater portion of both boulders and matrix is quite different. There are not now exposed any near-by hills from which these materials might have been brought down, nor is there good reason to believe that such hills existed in Huronian times. The nearest outcrops of Laurentian rocks from which many of the boulders may have been derived are some miles distant. Many of the large boulders are quite unlike any rocks which have been found in place in the district. Evidently ice was the most competent agent to bring such materials to their present position, and to deposit them in such a heterogeneous manner.

At Temagami the conglomerate lies on and at its base contains numerous fragments of Keewatin schists. The conglomerate also contains numerous rounded and subangular boulders of rocks not found close by. The underlying rock presents a fairly fresh but not a smooth surface. The matrix of the basal conglomerate contains numerous well formed rhombohedra of siderite and similar crystals are abundant in shale and quartzite beds in the conglomerate. They are evidently derived by weathering from the adjacent iron formation, and the crystals were growing freely contemporaneous with the mechanical deposition of clay, sand, and boulders. It is probable therefore that the conglomerate was formed under water and that there was carbonate in solution. If the larger erratics were brought by ice it was probably not land ice.

Summary—In appearance the conglomerate-quartzite-shale series of the Huronian represents nothing so closely as compacted glacial and glacio-fluvial debris. The finding of striated and soled pebbles confirms the supposition of such an origin. The character of the contacts thus far found do not disprove that glaciers placed the basal conglomerate, though they suggest that such was not the case.

There are some sudden transitions from shale to coarse conglomerate which suggest that the earlier deposits may have been overriden by land ice. It seems probable however that part of the material was deposited under water and that floating ice contributed its load of glacier derived material.

There is no reason for supposing that the thick boulder free beds of shale and greywacke are not ordinary water lain sediments, though they may contain glacial flour.

Michigan College of Mines, Houghton, Mich., April, 1910.

THE CONTOUR OF THE SYLVANIA SANDROCK AND RELATED STRATA IN THE DETROIT RIVER AREA.

REV. THOMAS NATTRESS.

The beds exposed within the new Livingstone Channel cofferdam at Stony Island, in Detroit River, do not at first sight offer any decisive clue to their horizon such as the Devonian at the mouth of the Salt Shaft at South Detroit affords; and have, perhaps as a consequence, been mistaken by high authority for Later Silurian deposits, whereas they are older than the Sylvania Sandrock.

Stony Island itself forms a part of the wall of the cofferdam, at the west side of the dam. If we take this island as a centre we shall find Sylvania sandrock S.W., in the extreme S.E. corner of Wayne County, in Michigan; S., on the foot of Bois Blanc island; S.E., off Bois Blanc, in the east channel of Detroit river and on Elliot's Point, in the Dr. Green Shaft; S.E. x E., in the Caldwell Grove well; E. x N.E., in the Sucker Creek test hole in Anderdon; N.E., approaching Lake St. Clair; N., in the Salt Shaft at South Detroit; and N.W., in rock wells in Wyandotte.

The area unwatered inside the cofferdam falls away toward the S.W., S.E., N. E.; W., S., E., and N. Within this area the rock cutting for the new channel that is being made to facilitate navigation, reveals an anticlinal formation of Silurian rock.

The cap of the anticline within the cut is abreast of Stony island, the island itself being the highest part of what has been an insular uplift since somewhere in Silurian time, a part of the great Cincinnati anticline.

South from the cap of the Stony island anticline the strata bank up against it at an angle to the south limit of a block that has faulted. Southward of this the dip of the newer strata is much greater. In a distance of 300 paces from the point where the strata begin to bank up against the *highest* elevation of the weathered anticlinal surface within the cut an additional 30 feet of strata are picked up; and in a total of 3,330 feet in length of exposure there is a depth of 55 feet of rock of higher horizon than the cap stratum of the anticline.

At the south end of the area excavated within the dam a minimum of five feet of rock required to be removed to get contract grade; at the north end, 5,500 feet from south end, 6½ feet; and 21 feet at highest elevation, about midway between.

South of the cofferdam, (and within the lower reach of its distance, before the dam was built,) dredges worked to advantage. Still southward, and west of Bois Blanc island, dredges went to grade without assistance of the drill, working in a mud bottom.

The conclusion is: this rapid southward dip of strata, traced now to the close neighborhood of the Sylvania on the foot of Bois Blanc, and on the west side of that island, contradicts the supposition advanced, figured, and made the basis of conclusions in "New Upper Siluric Fauna

from Southern Michigan," issued in 1907, by Professor W. H. Sherzer of Ypsilanti and Professor A. W. Grabau of New York, conjointly, and bearing the imprimatur of Dr. Alfred C. Lane, then State Geologist for Michigan.

The ascertained fact, revealed by the Dr. Green Shaft at Elliot's Point —— that the Sylvania sandrock, which is a surface extension abreast of the south third of Bois Blanc island and across the river bottom of the east channel, has disappeared *southward* in a distance of a few hundred yards till it lies under about 25 feet of Silurian strata, shows where the sandrock belongs.

Sherzer and Grabau represent it as dipping under the Stony Island anticline.

The rock in the channel immediately west of Bois Blanc has all been scraped in dredging, where mud-covered. The drill has been used to a depth of 14 feet where the rock surface rises again, 6,500 feet south-south-west from the south third of the island. No sandrock has been touched, as it would have been had it extended across Detroit river. The reason is *IT DOES NOT BELONG THERE.*

When Schuchart of the U. S. National Museum at Washington prepared his paper "On the Faunal Provinces of the Middle Devonic of America, etc." and published in The American Geologist in September, 1903, he made use of two palaeographic maps, one of Onondaga time, the other of Hamilton time. It is evident to me from study of the Stony island cut and of the Sylvania sandrock exposures and elevations, that he does not figure either the Cincinnati Peninsula in the one case or the Cincinnati island in the other, as extending as far north as they did extend. There doubtless has always been more or less of a trough—perhaps a succession of troughs—across the peninsula or island between the head of it as figured by Schuchert and the actual head of it as constituted by the pre-Sylvania anticline known as Stony island and associated area in Detroit river.

The proximity of the west and east sides of Detroit river, and the close neighborhood of the corresponding exposures of Sylvania, have hitherto blinded everybody concerned to the fact that *these respective exposures are on opposite sides of the Cincinnati anticline.*

The contour of the Sylvania sandrock follows from the Ohio state line, about where it is joined by the county line between Monroe and Adrian counties, diagonally across Monroe and into the extreme south-east corner of Wayne county. And then, (as I am persuaded,) follows approximately the line of the west or Trenton channel of the river till it rounds the head of the northern projection of the Cincinnati anticline about or beyond the head of Gross Isle; thence circling into and through Sandwich and Anderdon townships in the county of Essex, Ontario, it has its first exposure as a surface extension in Canada—and probably the only one—in the bed of Detroit river and on Bois Blanc island, at the southern limit of Amherstburg. Thence it *strikes south-eastward* and is found under some 222 feet of "fossiliferous limestone" on Pelee Island; and might be expected to show in rock wells along a line from Sandusky Bay to Adams county, Ohio, and approaching—if not crossing—the Kentucky state line.

There is an associated problem presented in the Salt Shaft at South

Detroit. Down under 189 feet of Silurian dolomite there is a deposit of limestone 38 feet in thickness, carrying what have hitherto been recognized as chiefly Devonian fossil forms and not belonging to the Silurian age. These have been identified by Grabau as very similar to those of the Anderdon beds of high-grade limestone (99% Ca CO_3) to which, as a faunal zone of distinctive character, he has given the name "zone of Idiostroma nattressi."

Sherzer and Grabau have therefore concluded that this 38 feet of limestone in the shaft is the Amherstburg beds intercalated.

It may therefore be of interest to locate the rocks above the Sylvania in relation to it as a permanent base, and in relation one to the other, —at various points around the shore of the Detroit river reach of the Cincinnati anticline. As we shall be able to follow this old shore-line from drill core to rock well, shaft and test hole, the area is approximately of horse-shoe outline. The left heel of the shoe will mark the Sylvania in the extreme south-east corner of Wayne county. If there be four nail-holes on each side of the shoe, the first one from the left heel will mark Horse Island and sandrock. The second one will mark the Sibley quarry at Trenton. The third marks the Wyandotte well, the log of which is given in Vol. V., Geological Survey of Michigan, Plate LXVI. The fourth hole locates the Salt Shaft at South Detroit. Let Windsor Salt Well No. 11, (See State Board of Geological Survey of Michigan report, 1901, p. 218,) be indicated by the toe-calk of the shoe; then the second nail-hole on the right will just about mark the Sucker Creek test hole. The third one marks the Amherstburg quarries in Anderdon. The fourth marks the Caldwell Grove well. And the right heel of the shoe will mark the Dr. Green Shaft to the Sylvania at Elliots Point.

Here is the comparative statement:

At Sibleys there is a Corniferous (Dundee) deposit over a heavy stratum of magnesian limestone, immediately under which (as shown by drill cores) is a Stromatopora "reef" associated with what Grabau has described as "calcilutite," a compact brittle limestone, precisely as in the "Anderdon beds" in the Amherstburg quarries, in Essex county.

In the Wyandotte well there is 50 feet of "Dundee," (no subdivision reported in the well record) and 105 feet of dolomite, above 60 feet of Sylvania. Presumably the Anderdon beds—the coral stromatopora "reef" and the compact calcilutite (Grabau) are present; for the distance from Sibleys is very short, and the depth recorded as Dundee is sufficient, and was so named before the "Anderdon" beds were discovered, —by comparison with both the Amherstburg and Sibley quarries.

At the Salt Shaft is 63 feet of Dundee (again sufficient depth for the Anderdon beds to be present, other things being equal;) and 189 feet of "Lucas" dolomite next under this depth of Dundee. (Evidently we are getting *off shore further* from the Cincinnati uplift.) Next below is 38 feet of limestone which Sherzer and Grabau together claim is the "Anderdon" limestone, intercalated. That is the problem.

Under the problematical 38 feet is 47 feet of Flat Rock dolomite, resting upon 117 feet of Sylvania; the increased depth again suggesting greater distance off shore from the Cincinnati anticlinal than at Wyandotte, a heavier deposit in a deeper sea.

In the C. P. R. Salt Well, No. 11, at Windsor, are "dolomites" to a depth of 300 feet, reported upon by an authority to whom it had not then become necessary in the solving of Detroit river area problems, to distinguish with precision between dolomites and limestones, for the problems had not yet developed. Below this is 25 feet of "dark petroliferous limestone." (Compare the 38 feet of problematical deposit in the Salt Shaft with this.) Then follow 210 feet of dolomites, etc., above 55 feet of Sylvania.

The question is: Is the Anderdon included in the one case? and: Is this latter the problematical limestone?

At the Sucker Creek test hole, there is 90 feet of gray limestone at the top, which effervesces briskly. The location is about six miles from the Amherstburg quarries—where is the only recognized surface extension of, and the maximum depth of the Anderdon beds. Under the 90 feet is 260 feet of brown dolomites, resting upon 30 feet of Sylvania. In the proximity of 400 feet down from surface, or toward the bottom of the dolomites which rest upon the sandrock, considerable effervescence is observable. (With this compare the "petroliferous limestone" of the Windsor salt well, and the problematical 38 feet of the Salt Shaft).

The question again is: Is the Anderdon included in the one case? and: Is this latter the problematical limestone of the Salt Shaft?

The Amherstburg quarries have already been described in contrast with Sibleys, and have been stated to be practically identical—except for the later beds of thin-bedded Coniferous (Dundee) at Sibleys, and a maximum depth of Anderdon beds at the Amherstburg quarries.

The Caldwell Grove well recorded in Brummel's "Natural Gas and Petroleum in Ontario," 1892, has 252 feet of "limestone," (compare as regards lack of precision in the use of terms, "dolomite" in record of surface deposits at Windsor salt well;) resting upon 60 feet of sandrock.

The Dr. Green Shaft at Elliots Point has 25 feet of dolomite above the Sylvania, with no Devonian overlying. This is at about the waistline, so to say,—the narrowest part—of the Cincinnati anticline, the distance across from Elliots Point to the Huron River.

I have attempted to suggest to you—without sufficient accurate knowledge as yet being available for proof—that the contour of the "Anderdon beds" is continuous throughout the area traversed between the extreme points, Elliots Point in Essex county, Ontario, and the southeast corner of Wayne county, Michigan, in the near neighborhood of which extreme points the Anderdon is acknowledged to be present.

I have also attempted to suggest to you with some show of reason—but again with only the same limited sources of inexact but suggestive knowledge—that the supposed intercalated beds have, through at least a great part of the same area and distance, *their own independent horizon.*

Amherstburg, Ontario, Canada, April, 1910.

PLATE I.

A. Surface striping in rock debris on steep side of Asulkan Pass, Selkirk Mountains. The view looks down slope from a snowdrift.

B. Striping on the steep slope of the Asulkan névé, Selkirks. The effect is most marked in the left foreground and to the right of the center in the view.

SOIL STRIPES IN COLD HUMID REGIONS, AND A KINDRED PHENOMENON.

WILLIAM H. HOBBS.

Attention was first strikingly directed to surface rock flowage as a characteristic degradational process in humid regions and high latitudes by Professor J. G. Andersson of the University of Upsala.[1] For this process, the importance of which had not before been adequately recognized, he proposed the name *solifluction* (*solum*, soil; *fleure*, to flow). Striking examples of the process he had himself studied in detail from Bear Island (74½° N. latitude), and from the Falklands (52° S. latitude), where are the famous "stone rivers." These streams of mixed rock debris and clay, while bearing considerable resemblance to the "mud rivers" early mentioned by Hayden from the North American Rockies and more recently described in detail by Howe,[2] are considerably longer and narrower and relatively thicker.

Andersson's paper, which is a preliminary notice, discusses the larger characteristics only of these interesting streams of rock debris. In one place, however, he refers to a streakiness of the surface of the moving rock debris on Bear Island. Nordenskjöld,[3] on the other hand, has furnished us with much new and general information concerning solifluction, both as regards the localities described by Anderson and others which he has himself examined.

Speaking in general of the surface of these flows, Nordenskjöld says:

"Often there appears upon the slopes of hills a band-like arrangement of the debris. If one examines it more closely, he perceives that these bands consist of irregularly heaped up masses of angular stones, debris and clay slime, which extend almost from the summit of the hill down to the valley, where they stretch out after the manner of glaciers and push ahead of them a true terminal moraine of rock splinters which are cast aside" (page 61).

A fine example of surface striping by this process Nordenskjöld has figured from Graham Land (Pl. 2, B.), and he refers to a similar observation made long before in Greenland. Of this latter example he says:

"I found that the debris on steeply inclined slopes often had a peculiar arrangement. The slope appears as though striped, because narrow generally parallel bands of finer or coarser debris or clay alternate in close sequence. The entire earth-mass is ordinarily well sorted, so that each band as a rule consists of equally large sand grains or stones" (pp. 62-63).

These bands continue down the slope in more or less serpentine courses becoming always fainter, however, as the gradient becomes flatter and passing finally into a peculiar net-like arrangement of the debris on the lower levels.

[1] J. G. Andersson, Solifluction, a component of subaerial denudation. Jour. Geol., Vol. 14, 1906, pp. 91-112.

[2] Ernest Howe, Landslides in the San Juan Mountains, Colorado, including a consideration of their causes and their classification. Professional paper No. 67 U. S. Geol. Surv., 1909, pp. 1-58.

[3] Otto Nordenskjöld, Die Polarwelt und ihre Nachbarländer. Leipzig. 1909, pp. 60-65.

Andersson's observation that solifluction is a phenomenon particularly characteristic of inhospitable regions, seems to be confirmed by the observation of Howe in the Rocky Mountains. The rock streams which he has described from that region are always found originating beneath the steep walls of abandoned glacial cirques in high altitudes.

Nordenskjöld has brought out the interesting fact that the debris stripes are always developed below the rim of a great snow drift, which in melting has so saturated the debris as to transform it into a thick paste, and thus allow it to slide slowly down the slope.

In the month of August, 1909, the writer discovered identical striped debris zones on the steeply inclined side slopes of the Asulkan Pass above the névé of the Asulkan glacier (see plate 1, A). Here, also, the stripes ran in gently curving courses in the direction of the steepest slopes, making their start at the lower edge of a drift of snow. Thus the observation is in every way confirmatory of those made by Nordenskjöld. The dark lines in the illustration are slight trenches within which no larger rock fragments are found, and they appear to correspond to lines of maximum near-surface flow of the rock paste, here largely of mud. The flat rock fragments lying between the trenches, form an imperfect plating of the intervening ridge so that it sheds the water as does a pent-house.

Upon the Asulkan névé below the pass the surface layer of the snow has been grooved by a process which perhaps has something in common with that which arranged the debris in parallel bands. The effect of this surface striping, or venation, is brought out in Plate 1, B. Starting from near the upper margin of the névé, nearly parallel ridges and grooves descend so as always to conform to the lines of steepest gradient upon the surface, eventually coalescing to form a somewhat larger trunk groove which follows the lowest line of the névé surface. Unlike a drainage system the tributaries travel beside the trunk for a considerable distance before making junction with it. This surface grooving or venation upon the névé is best shown upon the plate near the left, and also near the right-hand margin of the newer snow. That it is due to water drainage is evident from the fact that the lines do not continue beyond crevasses which intersect their course. It is suggested that the melting of the outer zone of the névé granules by filling up the spaces between them with water, affords temporary conditions similar to those of a thin layer of sand partially saturated with water and lying upon a slope. There is thus considerable resemblance between the surface venation of the névé and the striping in the rock debris on steep slopes below summer snow drifts.

This phenomenon of soil striping in debris which has been saturated with water, can hardly be considered apart from the well-known "barrancas" which develop on volcanic tuff cones after each new eruption, so soon as the first rains have saturated the material with water (See plate 2 A). Here also the stripes follow the steepest slope. A comparison of the Asulkan and Greenland soil stripes with the great barrancas, suggests that the width of the ridges which develop is in some way a function of the viscosity of the rock paste, which in turn is doubtless dependent upon the nature, form, and size of the materials, the degree

PLATE II.

A. Barrancas formed on the tuff cone of Mount Vesuvius after the rains subsequent to the eruption of 1906, (after Lacroix).

B Stripes on the surface of rock debris in Graham Land, West Antarctica, (after Otto Nordenskjöld).

A type of a waste filled valley. The fresh cliff is not found in many.

of saturation, the thickness of the saturated layer, the steepness of the slope, etc. The problem here involved would appear to be one that would repay an attempt at mathematical solution based on the known laws of flow of viscous bodies. That a differentiation of the mass into alternate bands of relatively more and less fluid materials, and that the width of these bands determines the width of the visible stripes seems almost certain.

University of Michigan, March 10, 1910.

A WASTE FILLED VALLEY.

A. E. PARKINS.

(Abstract.)

From an examination of ten or twelve valleys of intermittent streams along the Huron River between Ypsilanti and Dexter, the writer found that invariably where these valleys headed in cultivated fields, the valleys are waste filled and have flat floors. This would lead one to suspect that such filling was produced by an increase in supply of material from the head waters, due to the cutting away of the forests.

The accompanying picture is an example of one of the best of such valleys. That filling has taken place is evident from the following lines of evidence:

(1) The flatness of the floor, which in a valley of such great slope should be V-shaped;

(2) The sharp angle that the sides make with the valley bottom;

(3) The partial burying of the trees;

(4) The interesting features shown by the stump and the 5 ft. cliff to the right. Just above the upper parts of the root of the stump is a line of muck, and marks the position of the valley bottom before filling. The deposits above this layer of muck are 2½ ft. thick. By a count of the rings on the stump, the tree when cut was 75 years old. Filling has taken place some time since the tree was a sapling growing in the valley bottom.

Another characteristic of all such valleys is the great number of steps, caused by stones and twigs damming the channel at various points, and, also, perhaps by the recession of the steps.

In such streams the post-glacial cycle of erosion has been interrupted by an increase in supply of waste from the headwaters. These valleys may serve then as local examples of what took place during the close of the Glacial Period in all valleys of south flowing rivers.

M. S. N. C., April, 1910.

REPORT UPON THE PROGRESS OF THE BIOLOGICAL WORK OF THE MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY.[1]

ALEXANDER G. RUTHVEN.

Mr. President and Members of the Michigan Academy of Science:

At the December meeting of the Council a motion was carried to request of the director of the Michigan Geological and Biological Survey a report upon the work that has been done by, and the present status of, the biological survey of the state, which the academy was so instrumental in founding. The director, Mr. Allen, has requested me to make this report, for since 1907, when the Board of Geological Survey, upon the recommendation of the Board of Scientific Advisors, appointed me Chief Field Naturalist of the survey, I have been very intimately connected with the biological work.

In order that I may bring the matter clearly before you, permit me to give you a very brief historical account of the state geological and biological surveys. The first survey was inaugurated in 1837, immediately after the admission of Michigan into the Union. The act read as follows:

> That the Governor is hereby authorized and directed to nominate, and by and with the advice and consent of the senate, to appoint a competent person, whose duty it shall be to make an accurate and complete geological survey of this state, which shall be accompanied with proper maps and diagrams, and furnish a full and scientific description of its rocks, soils and minerals, and of its botanical and geological productions, together with specimens of the same; which maps and diagrams and specimens shall be deposited in the state library, and similar specimens shall be deposited in such literary and scientific institutions as the governor shall direct; and the governor is further authorized to appoint from time to time, as the exigencies of the case may require, competent persons to act as assistants under the direction of the Geologist.[2]

Alexander Winchell[3] states that this act "provided for a geological, zoological, botanical and topographical survey," from which I infer that in the reference to "botanical and geological productions" in the act the word geological is a misprint for zoological.

In the following year the governor approved a new act organizing the survey on a more comprehensive basis. This act stated definitely that the survey should consist of four departments, "first, geological and mineralogical; second, zoological; third, botanical; and fourth, topographical," that three chief assistants to the state geologist should be appointed, a zoologist, a botanist and a topographer, and that the duplicate specimens should be deposited at the state university[4]. Under this law work went on until the close of the year 1841, and until 1845 in connection with the United States surveys. It is interesting to note that this first survey was organized on a broader basis than any of the

[1]Delivered before the general meeting of the Michigan Academy of Science, April 2, 1910.
[2]Laws of Michigan, 1837—No. XX.
[3]First Biennial Report of the Progress of the Geological Survey of Michigan, 1861, p. 7.
[4]Laws of Michigan, 1838—No. 49.

later ones; that it was, in fact, what we are striving for at the present time, and that it was terminated by the same difficulty that confronts us,—difficulty in obtaining the necessary funds from the legislature.

In 1859 the survey was reorganized on nearly the same basis as the original one, but appropriations were provided for only two years. The act was entitled "An act to finish the geological survey of the state," and read as follows:

That the Governor is hereby authorized and directed to appoint a competent person, whose duty it shall be to finish the Geological Survey of the state, which shall be accompanied with proper maps and diagrams, and shall furnish a full and scientific description of its rocks, soils and minerals, and of its natural productions, together with specimens of the same; which maps, diagrams and specimens, shall be deposited in the library of the State University, and the library of the Agriculture College, and similiar specimens shall be deposited in such other library [literary] and scientific institutions in the state as the Governor shall direct; and the Governor is further authorized to appoint, from time to time, as the exigencies of the case may require, competent persons to act as assistants, under the direction of the Geologist.[1]

One important feature of this act was that the University of Michigan and the Michigan Agricultural College were specifically designated as depositories of the collections.

In 1869 a geological survey was again organized and has continued to the present time. The sections of this act relative to the scope of this survey read as follows:

Sec. 1. That the Governor, the Superintendent of Public Instruction, and the President of the State Board of Education shall constitute a Board of Geological Survey; they shall control and supervise the continuation and completion of the geological survey of the state; they shall appoint and commission a suitable person, possessed of the requisite knowledge of the Science of Geology, who shall be director of the geological survey hereby instituted.

Sec. 4. It shall be the duty of the director to make or cause to be made, a thorough geological and mineralogical survey of the State, embracing a determination of the succession, arrangement, thickness, and position of all strata and rocks; their mineral character and contents, and their economic uses; an investigation and determination of the organic remains of the State; a general examination of the topography, hydrography, and physical geography of the State; an investigation of the soils and subsoils, and the determination of their character and agricultural adaptation; the investigation of all deposits of l rines, coal, marl, clay, gypsum, lime, petroleum, metals, and metallic ores, building stone, marble, grit-stone, materials for mortar and cement, mineral paint, and all other productions of the geological world within the limits of this State capable of being converted to the use of man.

Sec. 5. It shall be the duty of the director to collect ample materials for the illustration of every department of the geology and mineralogy of the state, and to determine, catalogue, and label the same, and prepare them for exhibition to the citizens of the state, in suitable cases, in the museums of the State University and State Agriculture College, at the State Normal School, and such other colleges of the state as may make application to the board prior to the making of the geological survey, and obligate such colleges to pay the extra expense necessarily incurred in furnishing such specimens.[2]

I would like to call your attention to two deficiencies in this act. First, no natural history work is provided for, as was the case in the previous surveys, and, second, the survey was given no official name.

For several years previous to 1905, you as members of the academy, realizing the opportunities that were being neglected to advance our

[1]Laws of Michigan, 1859—No. 206.
[2]Laws of Michigan, 1869—No. 65.

knowledge of the natural history of the state, a condition of affairs that was putting us far behind our sister states, endeavored to remedy the matter by obtaining a biological survey of the state. Finally, in 1905, there was passed by the legislature and signed by the governor a bill that provided for such a survey. This, while but a small beginning, has done much toward giving us a start in the right direction. The act read as follows:

> That the Board of Geological Survey ..... is hereby authorized and required to make under the direction of the State Geologist, appointed by them, a thorough biological survey of the state, embracing a determination of the range and distribution of the various plants and animals inhabiting the state and the relation to their environment and the welfare of man.[1]

Permit me to call your attention to three features of this act. First, the biological work is given as permanent a foundation as the geological; second, no permanent appropriation is provided; and, third, no place is designated as a depository of the collections. At this time, $1,000 a year for two years was provided, and this appropriation was voted again in the sessions of 1907 and 1909. In view of these things Mr. Allen, the director, on the advice of the Board of Scientific Advisors and with the approval of the Board of Geological Survey, has changed the name of late years applied to the survey, "Michigan Geological Survey," to the "Michigan Geological and Biological Survey," and the Board of Geological Survey has designated the University of Michigan Museum as the depository of the collections. At the present time then, we have, as a result of the labors of the friends of natural science in the state, "The Michigan Geological and Biological Survey," and funds to continue the biological work until June 30, 1911.

As the funds available for the biological work have been absurdly insufficient, we have limited the work to that which we believe can be done to the best advantage with our limited facilities. It falls into two classes—explorations of particular regions and monographic studies of different groups in the state. I believe that the reports from these two kinds of work may be made to serve two ends—the advancement of scientific knowledge and the assistance of teachers and local students. What we have done so far I will put before you in a review of the work we have published, have in press, or in preparation.

The publications of the survey to date are as follows:

1906. An Ecological Survey of Northern Michigan. Prepared under the direction of Charles C. Adams. Annual Report of the Geological Survey of Michigan, 1905, pp. 1-133, 4 maps, 17 plates. A detailed account, by the field workers and various specialists, of the fauna and flora of the Porcupine Mountains and the southern part of Isle Royale, based upon the material obtained by an expedition sent out by the University of Michigan Museum on funds provided by private individuals.

1906. An Illustrated Catalogue of the Mollusca of Michigan. Part I, Terrestrial Pulmonata (Land Snails). By Bryant Walker. Annual Report of the Geological Survey of Michigan, 1905, pp. 427-531, 169 text figures, 1 plate, 1 chart. A manual of Michigan land snails, summarizing the status of the forms in the state, and giving keys and descriptions designed to assist students of the Michigan fauna.

[1]Public Acts, 1905—No. 250.

1907. Peat: Essays on its Origin, Uses and Distribution in Michigan. By Chas. A. Davis. Annual Report of the Geological Survey of Michigan, 1906, pp. 93-395, 19 plates, 19 text figures. An original investigation of the formation and distribution of peat in Michigan, with a discussion of its economic value.

1908. A Biological Survey of Walnut Lake, Michigan. By Thomas L. Hankinson; with chapters on the Physiography, Geology and Flora of the Region, by Charles A. Davis; and a paper on the Aquatic Insects of the Lake, by James G. Needham. Annual Report of the Geological Survey of Michigan, 1907, pp. 153-288, 3 maps, 60 plates, 6 text figures. The results of an examination of the fish environments of Walnut Lake, with special reference to the occurrence of the whitefish.

1909. Some Apparently New Thysanoptera from Michigan. By A. Franklin Shull. Entomological News, May, 1909, pp. 220-228, 7 text figures. This paper contains descriptions of new species and first descriptions of unknown forms of Thrips collected in Huron County by the author, while connected with the survey of 1908.

1909. An Ecological Survey of Isle Royale, Lake Superior. Prepared under the direction of Charles C. Adams. Annual Report of the Geological Survey of Michigan, 1908, pp. i-xiv, 1-468, 58 plates, 4 text figures, 1 map. A detailed discussion of the fauna and flora of Isle Royale, by the field workers and various specialists, based principally upon the results of the second expedition sent to this region by the University of Michigan Museum.

1909. Notes on Michigan Reptiles and Amphibians. By Alexander G. Ruthven. Eleventh Annual Report of the Michigan Academy of Science, pp. 116-117. Miscellaneous notes on Michigan amphibians and reptiles based primarily upon survey material.

1910. Carriker, M. A. and Shull, Charles A. Some New Species of Mallophaga from Michigan. Entomological News, XXI, pp. 51-57, 1 plate. Descriptions of five new species and one new subspecies of Mallophaga taken in Huron county by the 1908 expedition.

1910. A New Species of Musculium. By V. Sterki. The Nautilus XXIV, p. 3. The original description of a new species of mollusk, *Musculium pusillum,* from Dickinson county.

1910. Chrysophanus Dorcas and Related Species in the Upper Peninsula of Michigan. By W. W. Newcomb. The Canadian Entomologist, XLII, pp. 153-157, 2 plates. Some results of entomological investigations of the writer in Dickinson county while on the survey of 1909.

The publications that are being printed by the survey are as follows:

The Crawfish of Michigan. By A. S. Pearse.

The Insect Galls of Michigan. By Mel. T. Cook.

The Birds of School Girls Glen, Ann Arbor, Michigan: A Study in Local Ornithology. By A. D. Tinker.

A Preliminary Catalog of the Aboriginal Sites in Michigan. By Harlin I. Smith.

The following reports are in progress, or the manuscripts completed and awaiting publication:

A Biological Survey of the Sand Region on the South Shore of Sagi naw Bay, Michigan. A report upon the fauna and flora of the region, which was explored by a field party in the summer of 1908.

A Biological Survey of Dickinson County, Michigan. A report upon the investigations of a field party in the summer of 1909.

The Reptiles of Michigan. By A. G. Ruthven and Frances Dunbar.

The Butterflies of Michigan. By W. W. Newcomb.

The Mammals of Michigan. By N. A. Wood.

The Agarics of Michigan. By C. H. Kauffman.

Besides the work represented by the above reports the survey material has been borrowed by various specialists and used in work the results of which have been published elsewhere.

During the summer of 1910, the appropriations of the survey will be used in a botanical survey of a portion of the peach belt of Michigan, under the direction of C. H. Kauffman. In addition to this work a party of zoologists will be placed on the Charity Islands, Saginaw Bay, the necessary funds having been provided by Hon. W. B. Mershon of Saginaw.

I believe we are justified in saying that the results obtained so far decidedly exceed in value the amount expended in obtaining them, but I cannot close without giving the credit to whom it belongs. Much of the work has been done either by volunteers or by men who have done the work for their field expenses. In some cases we have paid small salaries, but in very few instances has the amount been more than a very nominal one. In addition to this many of you have given freely of your time and money to make the survey a success. To me one of the most pleasant features of the work, and one which I believe will do much to insure for the survey a prosperous future, is the way in which you have come to its assistance in those discouraging times, only too frequent, when we have unsuccessfully tried to make the available facilities cover the plans for work that we judged should be carried out.

NOTES ON MICHIGAN REPTILES AND AMPHIBIANS, II.

ALEXANDER G. RUTHVEN.

Since the last meeting of this section of the Michigan Academy of Science some noteworthy additional data on the amphibians and reptiles of the state have accumulated at the University of Michigan Museum. They are principally results of the biological investigations, in Dickinson County, conducted by the Michigan Geological and Biological Survey in the summer of 1909.

Rana septentrionalis Baird. Mink Frog.—This frog was found in abundance about the shores of Brown Lake, and occasionally along the west branch of the Sturgeon River in that vicinity. It was quite shy, never found away from the water, and seldom seen out of the water even on logs or mud flats. Nearly all of the individuals observed were sitting in the water with only the top of the head exposed.

The note at this time (July and August) was low pitched, and, although often sounded but once, was usually repeated from four to six times, and seemed to us, in the rapidity with which it was uttered and the pitch, to resemble quite closely the tap of a woodpecker on a dead tree.

In life there is considerably more yellow in the coloration of the back and sides than one would expect from an examination of alcoholic material. The light colored areas were, on the back C.C.[1] 207, on the sides C.C. 202, on the margin of the upper jaw C.C. 252. The dark colored areas above were uniformly black.

Elaphe vulpinus (Baird and Girard). Fox Snake.—The Fox Snake was found to be not uncommon in Dickinson County. The writer secured one specimen at Brown Lake, and observed the remains of another that had recently been killed near the same place. Mr. Albert Terrill, of Norway, informed us that it was not uncommon in that vicinity, and showed us six or eight skins of individuals that he had taken. The species seemed to be closely confined to the pine lands and is now apparently much rarer than formerly in this county, owing to the forest fires that recently swept over this territory.[2]

Chrysemys marginata bellii (Gray).—Dickinson County specimens of this genus of turtles prove to be referable to the variety *bellii*, thus extending the known range of this form in Michigan well to the east. Only two specimens (one of which was captured) were observed at Brown Lake; another was taken at Norway, where it was more common, and there is an immature individual in the Iron Mountain collection received from Mr. Royden Webster, Iron Mountain. The specimen taken in Brown Lake (July 1) had in the oviducts ten eggs, apparently ready to be laid.

Ann Arbor, Mich., April, 1910.

[1] Klincksieck and Valette, Code des Couleurs, Paris, 1908.

[2] In his summary of the known records of the Fox Snake in the state (Eleventh Annual Report Michigan Academy of Science, pp. 116-117), the writer overlooked the foot-note reference to its occurrence "in the vicinity of Saginaw Bay" in Miles "A Catalogue of the Mammals, Birds, Reptiles and Mollusks of Michigan" (First Biennial Report Geological Survey of Michigan, 1861).

VARIATION IN LYMNAEA REFLEXA SAY, FROM HURON COUNTY.[1]

H. BURRINGTON BAKER.

The shells used in this work were a set of about five hundred specimens of *Lymnaea reflexa* Say. They were obtained during the summer of 1908 by the Michigan Biological Survey, from the protected, sandy beaches of Saginaw Bay around Sand Point, which is the largest projection on the west side of the "thumb" of Michigan. They occurred there in large numbers, in shallow water, on floating driftwood and on masses of decaying sedges (mostly *Scirpus americanus*).

The work was begun to determine whether some peculiar, elongated specimens were simply regular variates at one end of a symmetrical curve or belonged to a more or less distinct variety. If the latter was the case, a bimodal curve would, of course, be expected.

The greatest length and the greatest width of the shells were measured and the ratio used was the length divided by the width, which in all cases was between two and three. The measuring was done with a Browne and Sharpe micrometer caliper, but it was found that extra precaution had to be taken in measuring the width, due to errors caused by the long axis of the shell not being exactly at right angles to the arms of the caliper. This difficulty was partly obviated by fastening the instrument to a block and tacking under it a piece of cardboard with a series of lines ruled parallel to the measuring arms and a series at right angles to them. With the assistance of these lines to orient the specimen, it was estimated that the measurements were accurate to about five one-hundredths of a millimeter.

In collating the data obtained, it was found that the ratios varied with the length and in the same direction; that is, the older or longer shells had much higher ratios than the smaller ones. This difference was considerably over one-half as much as the greatest difference between any of the ratios, so that a curve obtained by using all of the specimens would have been so obscured as to be entirely incorrect. These differences have been plotted in Figure 1.

The curve obtained by using shells of a single length was a comparatively regular, and quite symmetrical one, wherever the specimens were numerous enough to insure comparative accuracy. This means, of course, that we have apparently a case of "indeterminate, chance" variation, except that the length of the shells represent only approximately the actual time age of the specimens. Probably, however, this error is not very great, as the shells were all obtained from the same habitat. The variation of those of twenty-two and those of twenty-three millimeters in length is shown in Figure 2.

The variation of the ratio with age raises a question in regard to Dr. Adams' work on "Variation in Io,"[2] as in that he mentions that he

[1]From the University of Michigan Museum.
[2]Chas. C. Adams, Variation in Io, Proc. Amer. Assoc. Adv. Sci., Vol. 49, 1900.

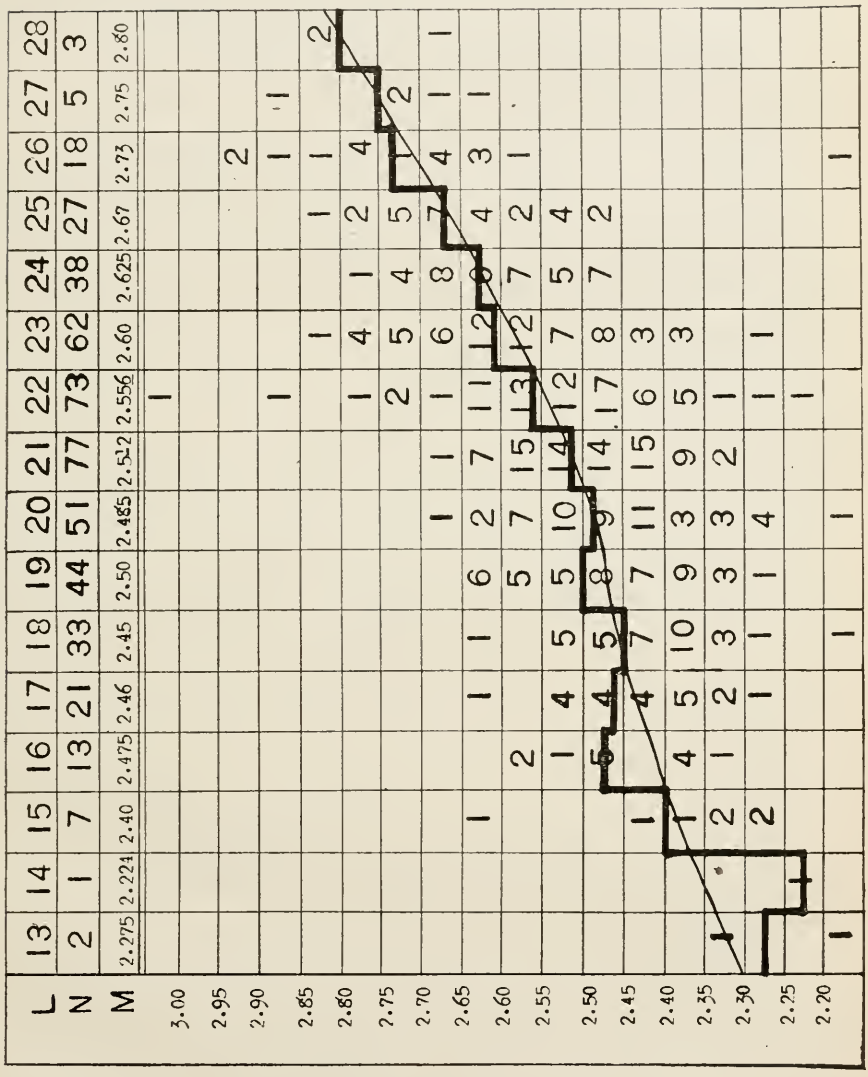
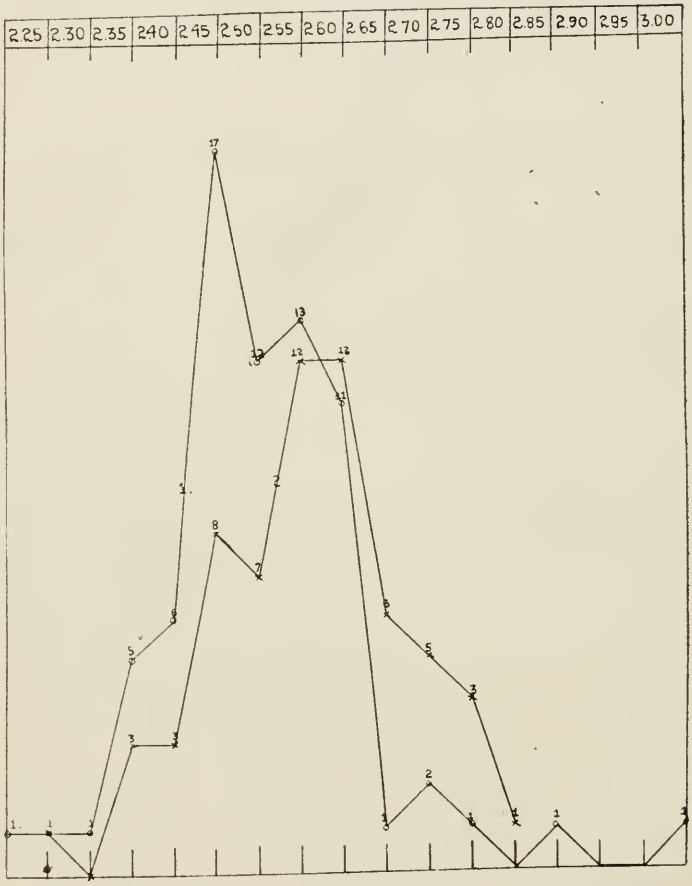


FIGURE 1. (For explanation, see page 63.)

FIGURE 2. (For explanation, see page 63.)



used both adult and young shells. The genus *Io* may not vary in this manner, but he makes no mention as to whether he determined this point. If fact, it seems to me that some of the remarkable variability curves obtained by him may be due to such a cause as the preponderance of specimens of certain ages.

EXPLANATION OF THE FIGURES.

Figure 1. Variation in the Mean Ratios of each Length.

L. Length of the shells in each vertical column in mm.

N. Number of shells of each length, i. e., in each vertical column.

M. Mean ratio (l/w) of shells of each length.

The numbers along the left hand side of the plate are the ratios represented by each horizontal line.

The numbers scattered throughout the plate are the frequencies of the square in which they occur, i. e., the figure 1 in the lower left hand corner indicates that there was one shell, 13 mm. long, with a ratio between 2.15 and 2.20.

The zigzag line represents the means, plotted by "the method of rectangles,"[1] while the continuous curve represents the probable variation of the ratios.

Figure 2. Variation of the Shells of Single Lengths.

1. Shells 22 mm. long (points represented by o).

2. Shells 23 mm. long (points represented by x).

These curves are plotted by the "method of loaded ordinates."[2]

The numbers at each point represent the frequency of each group.

The numbers along the top of the plate represent the ratios of each group.

Ann Arbor, Mich., April, 1910.

[1]C. B. Davenport, Statistical Methods with special reference to Biological Variation, New York, 1899, p. 13.

[2]Ibid., p. 12.

THE ORIGIN OF THE SECOND POLAR BODY.

CHARLES E. BARR.

A number of years ago I presented to the Academy a paper showing the origin of sexuality from asexual dimorphism. In this paper I offered a theory of the first polar body that time has served only to confirm. At that time I had not developed a fully satisfactory theory of the second polar body, though the paper indicated the line along which the answer should be sought.

The problem is by no means a simple one, involving, as it does, a complex interrelation of forces, the principles governing whose action have not yet been fully ascertained. I believe, however, that the time has now come when, through a process of exclusion, a fairly satisfactory conclusion may be reached.

Fertilization involves two processes, or two steps, of which the second is not necessarily present. These are: the entrance of the sperm into the ovum and the union of the germ nuclei to form a segmentation nucleus. It has been abundantly shown that a spermatozoon, entering an egg from which the nucleus has been removed, may yet inaugurate a full development. This obviously is due to the activity of the sperm alone, as has been conclusively demonstrated. A spermatozoon, then, under such favorable environmental conditions as thus afforded, can itself develop a new organism.

As shown in my previous paper, both ovum and sperm must have developed as asexual organisms, each of which, primitively had the capacity of independently continuing the race. In the case above cited, it is evident that this capacity has not necessarily been entirely lost in the case of the sperm. Possibly in some of the cases of parthenogenetic development the same may prove true of the ovum. However this may be, the case of Amoeba and other protozoans is sufficient to establish its truth.

Passing over the causes for the formation of the first polar body, which were adequately treated in my first paper, the crux of the problem, for the second, lies in the reducing division of the chromosomes which occurs preparatory to fertilization. It is evident that this cannot have arisen in "preparation" for an event that has not yet entered into the history of the race. Foresight is rare enough in mankind, and in animals it is assuredly a misnomer for hindsight, perpetuated. In seeking for the explanation of the phenomenon, therefore, we must look to the environmental conditions presented to the asexual, dimorphic individuals possessing the full number of chromosomes—and further, we must conceive the reducing division as primitively a result, rather than a preparation for fertilization, which has, in some way, been thrust back in the series of developmental stages, according to the well known principles of tachygenesis.

The solution of the problem, once these principles are grasped, is so simple that it is astonishing that they have so long escaped the attention

of embryologists. The entrance of the sperm into the enucleated egg, simply restores the power it had lost, owing to the deprivation of the nucleus. The entrance of the sperm into the egg which still retains its nucleus, at once brings it to the condition ordinarily and necessarily immediately precedent to division; that is, it doubles the number of chromosomes. It is, then, unnecessary for it to "rest"—which is to say, take the time necessary for the stages involved in the dividing of the chromosomes—and it immediately proceeds to inaugurate the developmental processes.

It must be remembered that this process was begun when the full number of chromosomes was present in both bodies. In the division that now takes place, the distribution of these chromosomes plays the important part. It is evident that those in which the chromosomes from each source were evenly distributed would have the advantage over the others and natural selection (or natural elimination) would in time establish these as the dominant type.

All this, were the conditions suitable for immediate development. But the very thing that led to the evolution of dimorphic individuals was the pressure of hardship which necessitated deferred development. The same causes, then, which were effective in producing the inequality of division that results in the "elimination" of the first polar body, again operate, and this at once, to divide off the second polar body.

The fertilized egg now contains the normal number of chromosomes and the second polar body the same. From this condition has been evolved the reducing division by a gradual shifting backward in development of a segregation of the chromosomes in both sperm and egg. In this way perfect fertilization, by which is meant equality in number of chromosomes from each source, has been effectively secured. That this segregation has not progressed to the same extent in sperm and egg is significant. The active spermatozoon has carried the process to the extreme of segregation before the last formative division; the more passive ovum scarcely completes it before fertilization is accomplished.

Albion, Mich., April, 1910.

TWO ABNORMALITIES IN THE CRAYFISH.

LUCIE HARMON.

Numerous instances of abnormalities in the crayfish have been reported from time to time, and various causes for such growths have been discussed, but as yet no definite conclusions have been reached. The two cases here described are presented with the hope that they may serve as additional material for a future solution of the causes of abnormal growth.

The first case to be described is that of an aberrant limb on a male *Cambarus virilis* (Hogen). The specimen was obtained from North Judson, Indiana. Though in other respects the animal is perfectly normal, the third right walking leg has five projections from the protopodite. The dactyl and index on the outer side of the leg are normal, but on the inner side there are three additional claws, two not articulated but about the size of normal claws; a third, lying between these two, very small, slightly movable, and deeply set in a socket. The pair of normal claws and the longest two of the abnormal claws have each one row of serrated plates arranged along their approximating sides. The tiny claw bears two rows of serrated plates, facing those of the large claws between which it lies. These are more pronounced on the inner than on the outer side and are longest on the tip. The four large claws bear horn-like tips, but this condition is not present in the tiny claw, though the latter has a slight protuberance on its posterior surface near the tip. On the anterior face of the distal third of the protopodite there is a slight injury, and this is located on that side of the leg from which the abnormal claws originate.

From the mass of literature regarding abnormal crustacean appendages I have selected the following citations as being most significant in their bearing upon the present case.

Nusbaum,[1] who worked upon chelipeds of crayfish thinks that abnormalities are due to enlargements which often accompany regeneration of broken parts.

Margaret A. Reed,[2] who was one of Prof. Morgan's students, reflects, in her investigations upon the hermit crab, the views which he held at that time. She says: "If after the leg of the hermit crab has been thrown off at the breaking joint, the base is split lengthwise, so that the nerve is divided or cut in two, there often appear two new legs, one connected with each end of the old nerve."

Herrick[3] describes eleven cases of abnormal appendages in the lobster, but only two of these are on ambulatory legs, one a bifurcating dactyl, the other a trimerous dactyl. He says, "Defective or deformed claws, the result of injury in different stages of repair, are met with every

[1]Nusbaum, Josef, :07. Kleiner Beitrag zur atavistischen Regeneration der Scheren beim Flusskrebse. Arch. f. Entw-mech., Bd. 24, pp. 124-130.

[2]Reed, Margaret A., :04. The Regeneration of the First Leg of the Crayfish. Arch. f. Entw-mech., Bd. 18, pp. 307-316, T. 17, 18.

[3]Herrick, F. H., '96. The American Lobster. Bull. U. S. F. C., Vol. 15, (1895), pp. 1-252, ls. 1-54.

F.g. 1. Abnormal third right walking leg of a male *cambarus viritis*. A, anterior surface: B, posterior surface.

Fig. 2. Ventral view of the abdomen of a female *Cambarus blandingiacutus*, showing an abnormal right first swimmeret.

day by dealers, while thousands of lobsters may be examined without meeting a single case of repetition or duplication of parts."

Most of Bateson's[1] variations described for Crustacea relate to chelae; only one is of a chelate ambulatory leg, two of antennae, and four of non-chelate ambulatory legs. He thinks that there is no ground to suppose that this doubling "is the result of injury or regeneration after injury." When the limb of a crab or lobster is injured, it is usually thrown off bodily, while the extra parts most often spring from the periphery of the chela. But since, according to Heineken, such mutilated parts are sometimes retained, this must not be insisted upon."

The second abnormality, Fig 2, was found in a specimen of *Cambarus blandingi acutus* (Girard). This crayfish possessed female characters, except for the fact that the first left abdominal appendage was exactly like that of a male in form, though its size was smaller than that of a normal male. The most careful dissection showed no sign of testes or male genital ducts, though the ovary was somewhat shrunken on the left side. The specimen had stood in alcohol for at least three months, however, and the shrunken condition may have been due to this cause.

Numerous examples of hermaphrodite crayfish have been reported. These are mostly females with some male organs. The most striking instance is that given by Hay[2] in which both male and female internal organs were present. I know of no published record, in this species of crayfish, at least, corresponding exactly to what I have described.

As to the cause of hermaphroditism Hay remarks, "It would therefore appear that in the genus Cambarus, at least, hermaphroditic individuals are females which, owing to some ambiguity of the formative cells in the embryo, have developed to a greater or less degree the characters of the opposite sex."

Andrews[3] is somewhat more specific on this subject: "Meanwhile the totality of facts known seems to mean that the gynandromorph crayfishes are caused by unknown disturbances, which may happen at various periods of ontogeny, though probably more often in the ovarian egg; that these disturbances may have no connection with the gonads; and that if in some cases the disturbances are possibly associated with polyspermy in general they seem more fundamental and deep seated amidst the causes of symmetrical form within the egg."

I have presented these abnormalities and some opinions of others who have worked upon the subject, making no attempt to say who is on the right track. Certainly the whole subject is open to much more investigation before it shall be settled.

Univ. of Michigan, April 12, 1910.

[1]Bateson, Wm., '94. Materials for the Study of Variation, p. 526.

[2]Hay, William Perry, :05. Instances of Hermaphroditism in Crayfishes. Smithsonian Miscellaneous Collections, Vol. 48, Part 2, pp. 222-228.

[3]Andrews, E. A., :09. A Male Crayfish with Some Female Organs. The American Naturalist, Vol. XLIII, No. 512, pp. 461-472.

A PRELIMINARY LIST OF THE CRUSTACEA OF MICHIGAN.

A. S. PEARSE.

It is not probable that this list contains nearly all the crustacea which occur in the State of Michigan. It is published at this time with the hope that it may prove of value as a summary of the present knowledge of the carcinological fauna of the state, and that it may arouse increased interest in this class of animals. The list has been largely compiled from the publications at the end of this paper; some species have also been added from the writer's personal records.

I had at first planned to publish keys to the genera and species, as well as to the sub-classes, orders and sub-orders. This plan was given up however, because the records for many of the orders were found to show only a fraction of the species which probably occur in the state. The following papers include keys by which the species of the various orders may be identified:[1]

Phyllopoda (1):—Packard ('83).
Cladocera (37):—Herrick and Turner ('95), Richard ('95).
Ostracoda (1):—Sharpe (:03).
Copepoda (25):—Forbes ('97), Marsh (:07), Schacht ('97, '98), Wilson (:04).
Amphipoda (6):—Weckel (:07).
Isopoda (6):—Richardson ('05).
Mysidacea (1):—Calman (:09).
Decapoda (9):—Ortmann (:05), Pearse (:10).

KEY TO SUB-CLASSES.

1. A variable number of body segments behind the head; no gastric mill; larva usually leaves the egg as a free swimming nauplius and passes through a metamorphosis; excretory organs are shell glands.....Sub-class *Entomostraca*, p. 68.
2. A definite number of segments behind the head (i. e. eight in thorax, seven in abdomen); gastric mill usually present; nauplius stage usually passed through in the egg; excretory organs are antennary glands.....Sub-class *Malacostraca*, p. 69.

KEY TO ORDERS AND SUB-ORDERS OF ENTOMOSTRACA.

1. Body distinctly segmented and covered by a cephalic carapace; post cephalic appendages leaf-like.....Order *Phyllopoda*, p. 69.
   a. Phyllopoda of considerable size; with 10-60 pairs of leaf-like swimming feet.....Sub-order *Euphyllopoda*, p. 69.
   b. Small Phyllopoda with compressed body inclosed in a bivalve carapace; four or five pairs of swimming feet; the biramous antennal are the chief organs of locomotion. Sub-order *Cladocera*, p. 69.

[1]The numbers after each order and suborder indicate the number of species already recorded from Michigan. The list includes a total of eighty-six species and subspecies.

2. Small entomostraca having body completely inclosed in a bivalved carapace, formed of articulated right and left valves; body unsegmented; abdomen rudimentary; only seven pairs of appendages.....Order *Ostracoda*, p. 71.
3. Small entomostraca, having an elongated body which is usually distinctly segmented; thorax bears three or four pairs of biramous appendages, abdomen has none; many are parasitic and show various stages of degeneration of structure. Order *Copepoda*, p. 71.
   a. Free living forms; eggs develop in a brood sac attached to the abdomen.....Sub-order *Eucopepoda*, p. 71.
   b. Ectoparasitic forms; body strongly depressed; no brood sacs.....Sub-order *Branchiura*, p. 72.

KEY TO ORDERS AND SUB-ORDERS OF MALACOSTRACA.

1. Small and shrimp-like; thorax covered by a soft carapace; thoracic appendages all biramous; eyes stalked....Order *Mysidacea*, p. 73.
2. Head and thorax united to form a cephalothorax which is covered by a carapace; three anterior pairs of thoracic appendages form biramous foot jaws, the posterior five pairs of walking legs are uniramous; eyes stalked.....Order *Decapoda*, p. 73.
3. No carapace, the first and sometimes the second thoracic segment fused with the head, the remaining seven are free; eyes sessile.....Order *Arthrostraca*, p. 73.
   a. Body compressed, or flattened from side to side. Sub-order, *Amphipoda*, p. 73.
   b. Body depressed, or flattened from above downwards. Sub-order, *Isopoda*, p. 73.

Order Phyllopoda.

Sub-order Euphyllopoda.

1. *Branchipus vernalis* Verril

This species was taken throughout the springs of 1909 and 1910 at White's Woods near Ann Arbor.

Sub-order Cladocera.

2. *Acroperus leucocephalus* Koch

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

3. *Alona affinis* Leyd.

Lake St. Clair (Reighard, '94).

4. *Alona guttata* Sars

Lake St. Clair (Reighard, '94).

5. *Alona lineata* Fischer

Lake St. Clair (Reighard, '94).

6. *Alona quadrangularis* Müller (=*A. oblonga* P. E. Mueller).

Marquette (Forbes, '91).

7. *Alonella rostrata* Koch

Lake St. Clair (Reighard, '94).

8. *Bosmina longirostris* O. F. M.

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

9. *Bosmina longispina* Leyd.

Lake St. Clair (Reighard, '94).

10. *Camptocercus rectirostris* Schdlr.

Lake St. Clair (Reighard, '94).

11. *Ceriodaphnia lacustris* Birge

Lake St. Clair (Reighard, '94).

12. *Chydorus globosus* Baird

Marquette (Forbes, '91), Lake St. Clair (Forbes, '91).

13. *Chydorus ruglosus* Forbes

Marquette (Forbes, '91).

14. *Chydorus sphaericus* O. F. M.

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94), Lake Michigan (Underwood, '86).

15. *Daphnella brachyura* Liev.

Marquette (Forbes, 91), Lake St. Clair (Reighard, '94).

16. *Daphnia hyalina* Leyd.

Lake St. Clair (Reighard, '94).

17. *Daphnia kahlbergensis interta* Forbes

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

18. *Daphnia kahlbergensis retrocurva* Forbes

Lake St. Clair (Reighard, '94).

19. *Daphnia pulex* De Geer

Specimens in the Michigan State Museum (Nos. 39052, 39053) were collected at Walnut Lake, Oakland county, August 25, 1906, at a depths of twenty and thirty meters respectively.

20. *Daphnia pulex pulicaria* Forbes

Lake St. Clair (Reighard, '94).

21. *Daphnia retrocurva* Forbes

Grand Traverse Bay (Forbes, '82).

22. *Eurycercus lamellatus* O. F. M.

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

23. *Graptoleberis testudinata* Fischer

Lake St. Clair (Reighard, '94).

24. *Holopedium gibberum* Zad.

Grand Traverse Bay (Forbes, '82), Lake Michigan (Underwood, '86), Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

25. *Ilyocryptus longiremis* Sars

Lake St. Clair (Reighard, '94).

26. *Latona setifera* O. F. M.

Lake Michigan (Underwood, '86), Lake St. Clair (Reighard, '94).

27. *Leptodora hyalina* Lillj.

Grand Traverse Bay (Forbes, '82), Marquette (Forbes, 91), Lake St Clair (Reighard, '94).

28. *Monospilus tenuirostris* Fischer

Lake St. Clair, Isle Royal (Reighard, '94).

29. *Ophryoxus gracilis* Sars

Lake St. Clair (Reighard, '94).

30. *Pleuroxus denticulatus* Birge

Lake St. Clair (Reighard, '94).

31. *Pleuroxus nanus* Baird

Lake St. Clair (Reighard, '94).

32. *Pleuroxus procurvatus* Birge

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

33. *Pleuroxus gracilis unidens* Birge

Lake St. Clair (Reighard, '94).

34. *Polyphemus pediculus* De Geer

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

35. *Scapholeberis mucronata* O. F. M.

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

36. *Sida crystallina* O. F. M.

Lake Michigan (Underwood, '86), Marquette (Forbes, '91), Lake St. Clair (Reighard, '94).

37. *Simocephalus serrulatus* Koch

Lake St. Clair (Reighard, '94).

38. *Simocephalus vetulus* O. F. M.

Marquette (Forbes, '91), Lake St. Clair (Reighard, '94). I took this species at "the overflow" at Ann Arbor, Nov. 20, 1909.

Order Ostracoda.

39. *Cypria esculpta* S. Fischer

Ann Arbor (Sharpe, :03). The writer collected this species at Ann Arbor, Dec. 21, 1908 and Nov. 20, 1909.

Order Copepoda

Sub-order Eucopepoda

40. *Achtheres corpulentus* Kellicot[1]

Michigan (Underwood, '86).

41. *Achtheres amblyoplitis* Kellicot[1]

Michigan (Underwood, '86).

42. *Canthocamptus minutus* Claus

Taken at "the overflow," Ann Arbor, Nov. 20, 1909.

43. *Cyclops albidus* Jurine

Lake St. Clair; Cheboygan, Charlevoix, Antrim and Emmet counties (Marsh, '97).

44. *Cyclops ater* Herrick

Lake St. Clair (Forbes, '97; Marsh, '97), Antrim and Charlevoix counties (Marsh, '97).

45. *Cyclops bicolor* Sars

Lake St. Clair (Forbes, '97; Marsh, '97), Cheboygan Co. (Marsh, '97).

46. *Cyclops bicuspidatus* Claus

Grand Traverse Bay (Forbes, '82), Marquette (Forbes, '91), Charlevoix, and Cheboygan counties, Lake Erie, Lake St. Clair, Lake Michigan (Marsh, '97). Taken in Oakland Co. in Walnut Lake, Aug. 25, 1906, at twenty meters; also at Ann Arbor during December, 1909.

47. *Cyclops edax* Forbes

Marquette (Forbes, '91).

48. *Cyclops fuscus* Jurine

[1]Parasitic on fish.

Michigan (Forbes, '97), Antrim Co. (Marsh, '97). Taken at Ann Arbor, Dec. 21, 1908.

49. *Cyclops leuckarti* Sars

Lake Erie; Lake Michigan; Lake St. Clair; Antrim, Cheboygan, Charlevoix, Ionia counties (Marsh, '97).

50. *Cyclops phaleratus* Koch

Lake St. Clair; Antrim and Cheboygan counties (Marsh, '97).

51. *Cyclops prasinus* Fischer

Antrim, Charlevoix, Cheboygan, Emmet, Ionia counties; Lake Erie, Lake St. Clair, Lake Michigan (Marsh, '97).

52. *Cyclops serrulatus* Fischer

Marquette (Forbes, '91); Antrim, Cheboygan, Charlevoix, Emmet counties; Lake St. Clair, Detroit River (Marsh, '97). Taken at Ann Arbor, Dec. 21, 1908, Nov. 20, 1909.

53. *Cyclops vernalis* Fischer

Taken at Ann Arbor, Dec. 21, 1908.

54. *Cyclops viridis brevisponosus* Herrick

Antrim, Charlevoix, Emmet, counties; Lake Erie, Lake St. Clair, Detroit River (Marsh, '97). Taken at Ann Arbor, Nov. 20, 1909.

55. *Diaptomus ashlandi* Marsh

Lake Michigan, Lake St. Clair, Detroit River, Charlevoix Co. (Marsh, '97); Michigan (Schacht, '97).

56. *Diaptomus minutus* Lilljeborg

Lake Michigan, Lake St. Clair, Detroit River; Charlevoix, Cheboygan, Emmet counties (Marsh, '97); Michigan (Schacht, '97).

57. *Diaptomus oregonensis* Lilljeborg

Lake Erie, Lake Michigan, Lake St. Clair; Antrim, Charlevoix, Cheboygan, Emmet, Genesee, Ionia counties (Marsh, '97), Michigan (Schacht, '97).

58. *Diaptomus reighardi* Marsh

Antrim, Charlevoix, Emmet counties (Marsh, '97).

59. *Diaptomus sicilis* Forbes

Grand Traverse Bay (Forbes, '82), Marquette (Forbes, '91), Lake Michigan, Lake St. Clair, Detroit River, Charlevoix county (Marsh, '97), Michigan (Schacht, '97).

60. *Epischura lacustris* Forbes

Grand Traverse Bay (Forbes, '82); Lake Michigamme (Forbes, '91); Lake Michigan (Forbes, '97); Lake Michigan, Lake Erie, Lake St. Clair; Antrim, Charlevoix, Cheboygan, Emmet, Genesee, Ionia counties (Marsh, '97).

61. *Lernacocera cruciata* Le Seur[1]

Michigan (Underwood, '86).

62. *Lernacocera pectoralis* Kellicot[1]

Michigan (Underwood, '86).

63. *Limnocalanus macrurus* Sars

Marquette (Forbes, '91), Michigan (Forbes, '97).

Sub-order Branchuira

64. *Argulus americanus* Wilson

Ann Arbor (Wilson, :04).

[1]Parasitic on fish.

Sub-class Malacostraca

Order Arthrostraca

Sub-order Amphipoda

65. *Dikerogammarus fasciatus* (Say)
Michigan (Underwood, '86), Lake Superior, Ann Arbor (Weckel, :07). Taken in St. Joseph county, April 13, 1909.

66. *Eucrangonyx gracilis* (Smith)
Ann Arbor, Isle Royal, Lake Huron, Lake Superior (Weckel, :07), Walnut Lake (Hankinson, :08).

67. *Gammarus limnaeus* Smith
Ann Arbor, Isle Royal, Marquette (Weckel, :07), Michigan (Underwood, '86).

68. *Hyallela faxoni* (Stebbing).
Specimens in the University Museum were taken at Isle Royal.

69. *Hyalella knickerbockeri* (Bate)
Charlevoix Co. (Ward, '97). Ann Arbor, Isle Royal (Weckel, :07), Oakland Co. (Hankinson, :08).

70. *Pontoporeia hoyi* Smith
Lake Michigan (Underwood, '86; Ward, '97; Weckel, :07).

Sub-order Isopoda

71. *Asellus communis* Say
Michigan (Richardson, :05).

72. *Cylisticus convexus* (De Geer)
Saginaw (Richardson, :05). There are specimens in the University Museum from Isle Royale and Ann Arbor.

73. *Ligidium longicaudatum* Stoller
Taken near "the overflow," at Ann Arbor, Nov. 20, 1909.

74. *Mancasellus tenax* (Smith)
Lake Huron, Lake Superior, Michigan (Richardson, :05).

75. *Mancasellus tenax dilata* Smith
Detroit River (Richardson, :05).

76. *Porcellio rathkei* Brandt
Saginaw (Richardson, :05). Taken at Ann Arbor frequently.

Order Mysidacea

77. *Mysis relicta* Loven
Lake Michigan (Smith, '74; Underwood, '86; Ward, '97), Grand Traverse Bay (Forbes, '82).

Order Decapoda

78. *Cambarus argillicola* Faxon
Detroit, East Saginaw (Faxon, '85). Gratiot, Saginaw, St. Joseph, Washtenaw counties (Pearse, :10).

79. *Cambarus bartoni robustus* (Girard)
Lake Michigan (Faxon, '85), Michigan (Adams, :07), Oakland Co. (Hankinson, :08). Alcona, Crawford, Oscoda, Wayne, Washtenaw counties (Pearse, :10).

80. *Cambarus blandingi acutus* (Girard)
St. Joseph county (Pearse, :10).

81. *Cambarus diogenes* Girard
Detroit (Faxon, '85), Oakland Co. (Hankinson, :08), Huron, Washtenaw, St. Joseph counties (Pearse, :10).

82. *Cambarus immunis* Hagen
Detroit (Faxon, '85), Huron, Saginaw, Washtenaw counties (Pearse, :10).

83. *Cambarus propinquus* Girard
Allegan, Calhoun counties (Faxon, '90), Saginaw, Cheboygan counties (Faxon, '98), Emmet, St. Clair, Washtenaw, Wayne counties (Ortman, :06), Crawford, Huron, Gratiot, Genesee, Oakland, St. Joseph counties (Pearse, :10).

84. *Cambarus rusticus* Girard
Lake Michigan (Faxon, '85), Saginaw (Faxon, '98).

85. *Cambarus virilis* Hagen
Calhoun Co. (Faxon, '90), Cheboygan Co. (Faxon, '98), Charlevoix Co. (Ortmann, :05), Crawford, Dickinson, Houghton, Iron, Marquette, Huron, Oscoda, St. Clair, St. Joseph, Wayne, Washtenaw counties (Pearse, :10).

86. *Palaemonetes exilipes* Stimpson
Wayne county (Smith, '74), Michigan (Underwood, '86).

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Ann Arbor, Mich., April, 1910.

A REMEDY FOR THE BLACK FLY PEST IN CERTAIN STREAMS OF THE SOUTHERN PENINSULA OF MICHIGAN.

CORA D. REEVES.[1]

In June, 1909, members of the engineering staff of the University of Michigan were driven from their camp on Douglas Lake in Cheboygan county by the black flies and at the end of the month it was deemed best to postpone for one week the opening of the Engineering Camp and the Biological Station on Douglas Lake on account of these pests. The conditions seemed to demand an immediate investigation and this was undertaken by the writer at the suggestion of Professor Reighard and under his direction.

Eggs, larvae and adults were collected and determined as Simulium venustum, an identification which was kindly confirmed by Professor O. H. Johannsen of the Maine Agricultural Experiment Station. No other species of black fly was found.

The adult is described by Comstock,[2] as about 5 mm. (⅕ in.) long, a stout-bodied fly with iridescent wings and very short, though sharp, biting mouth parts. The character of the mouth parts probably accounts for the fact that the fly usually inflicts the bite on the neck, or about the eyes or nose where the skin is thin. The few observations made tend to confirm the belief that where adults are numerous their breeding places are to be sought to windward and at no very great distances. They appear not to be strong fliers and are distributed from their breeding grounds, in part at least, by the wind. Those at the Engineering Camp came with little doubt from Carp Creek, a stream less than a mile southwest of the camp and none were seen or heard of more than two or three miles from a larva invested stream.

Comstock[1] tells of watching the adults dart into the water and out again and of finding the surface of a submerged rock coated with their eggs. The larvae are about 8 mm. (⅓ in.) long, club-shaped and attached by the posterior, larger end to some smooth solid, usually a rock. They are aquatic like the larvae of other gnats and mosquitoes and are found in swift water. They are usually to be obtained by sweeping the surfaces of the rocks and catching the dislodged material in a net. As there are no rocks in Carp Creep they were sought there by direct observation and by sweeping the logs and submerged branches, but without success. They were finally discovered by picking out pieces of bark which chanced to be lodged in the stream and to the smooth inner surfaces of which they were attached. They were also found attached to smooth leaves, such as those of the maple and beech which were caught and held in the stream. Small, smooth branches and twigs were often found covered with them. Thus a stick ¾ in. in diameter and not over four inches long had 221 larvae attached to it. They were found quite uniformly on the under surface of the object to which they were fastened and if the supporting surface was wide, they were apt to be at-

[1]Contribution from the Zöological Laboratory of the University of Michigan, No. 129, (Biological Station Series, Zöological Publication No. 1).
[2]Comstock, J. H., A Manual for the Study of Insects, 7th edition, Ithaca, 1907.

tached near its up-stream border. They were found quite uniformly near the water's surface and none were taken at a greater distance than ten inches below the surface. When found as far as ten inches from the surface their support was a stick which slanted into deeper water below them.

Light did not appear to have influenced the female in selecting the place for depositing the eggs, so that larvae were commonly found in sun-lit places, but also in darkness. Thus water was often heard gurgling underground over the roots of stumps in the cedar swamps adjacent to Carp Creek. In one such case the overlying moss and earth was removed to reach the water and a larva was found in it. The nearest opening to the surface was about two feet distant. *Temperature* of the water appears to have little influence in determining the location of the eggs or larvae. Larvae were found in water of 10° C. and in that of 25½° C. In the laboratory the larvae were found to endure for six hours temperatures of 31° C. to 35° C.

No larvae were found in the still pools of streams nor in the lakes. Probably they are unable to obtain food with their fan-like mouth parts except in rapid water.

The conditions necessary for the breeding of the flies thus appear to be rapid water and a smooth surface for the attachment of the larvae. All the conditions of light and temperature obtaining in this region appear to be suitable.

The remedy: Carp Creek and the other small streams flowing south from the ridge near which the Biological Station is located, run through sand and transport sand. Sand forms the banks and beds of these streams, and the logs and branches obstructing the stream soon become coated with it. Only the leaves, pieces of bark, logs and twigs that lie near the surface of the water and chiefly the lower, smooth surfaces of these are free from sand. Either the adult black flies do not attach their eggs to the sand-covered surfaces, or the larvae are unable to retain their hold on them, or the sand shifts and eggs and larvae are swept down stream. In any case the eggs and larvae are found attached only to the smooth sand-free surfaces and these lie near the surface of the water. To remove the twigs, branches, logs and lodged leaves that expose smooth surfaces free from sand would destroy the black fly larvae and make the stream unsuited for the breeding of black flies.

To determine whether larvae would be killed by removal from the stream or would make their way back to it, leaves with attached larvae were placed on land and the movements of the larvae watched. They were found to go to the lower parts of the leaves or to get between their moist surfaces. None of them moved more than two inches from the places to which they had been attached. Twenty-four larvae were watched; all were dead within forty minutes. Less than ten minutes on a *dry* surface sufficed to kill the larvae. *Hence to remove from the stream the smooth objects to which the larvae are attached should greatly lessen the black fly pest.*

It is evident that this method is available only in those streams in which silt or sand covers the bottom, but is of no value in shallow, stony streams. In such streams the use of heavy oil or the damming of the streams has been found effective.

Manistee, Mich., Apr. 1910.

CAN SEEDS BE STERILIZED?

RICHARD DE ZEEUW.

The work laid out in this study was to test the action of the following agents: cleaning fluid,[1] mercuric chloride, potassium dichromate, and formaldehyde gas, on each of the following seeds: *Lupine, Pea, Wheat, Corn* and *Mustard.*

The work can be conveniently divided into two parts. The first part has to do mainly with the seeds, the second mainly with the fungi and bacteria.

The first thing to be done is to determine the highest concentration and the longest period of exposure in each case which will still permit one to obtain a fair percentage of normal seedlings, leaving out of consideration for the time being the effect of the disinfectant on the adhering fungi and bacteria. A great deal of unnecessary and tedious work would be involved in determining the effect of the disinfectant on the fungi and bacteria adhering to the seeds while determining its effect on the germination of the seeds. The germination tests were carried on during the early fall when the laboratory had a normal temperature day and night of 22° C. This temperature was fairly constant. Lots of twenty-five seeds each were exposed for different lengths of time to different concentrations of each of the disinfectants, and after thorough washing were placed in a Geneva germinator kept at room temperature. They were left for four or five days and then were compared with the controls. These controls were treated as nearly as possible in a manner similar to the experimental seeds, except that no disinfectant was used.

After the highest point of both exposure and concentration had been determined for each kind of seeds in the different disinfectants, each kind of seeds thus treated was then tested to determine whether bacteria and fungi could endure this treatment as well as the seeds. For determining the latter point, an apparatus was constructed, the idea for which was obtained from Kehler's ('04) paper. It differs from Kehler's apparatus in that the seeds, after they are once placed in the disinfectant, are not exposed to contamination in any form till after a two weeks incubation. Kehler transferred his seeds by means of sterile forceps from the vessel in which they had been treated to the flask of culture medium.

The apparatus (see plate) is constructed as follows: There is a large flask, A, which contains distilled water and is connected with a three-arm glass cock, B. Flask A also has a glass tube, a, with a flange worked on the end. This tube projects into the flask through the rubber stopper. Over the flanged end of the tube is securely fastened a cap of cotton, b, to filter the air as it enters the flask when the water is drawn out of the flask. To the tube on the opposite side of cock, B, is attached a small flask, C. This flask has also an upright flanged tube,

[1] Cleaning fluid equals H_2SO_4 sp. gr. 1.83 saturated with $K_2Cr_2O_7$.

a′, with a cotton filter, b′. To the third tube of cock, A, is attached another small flask, D. In addition to the flanged tube, a″, with its cotton filter, b″, it has a third tube, c, entering it. This tube is drawn to a point, dips to the bottom of the flask, and is bent so as to end in the angle between the side wall and the bottom of the flask. Tube, C, is connected with cistern, E, which in turn is connected with an aspirator. Flasks A, C, and D are supported on a low ring stand.

The apparatus is operated as follows: Flask A is filled with distilled water; into flask C is put 25 cc. of agar medium; and E is disconnected after the rubber tube between D and E has been closed by means of a clamp. The whole apparatus (except the cistern) is then placed in the autoclave and sterilized. After autoclaving, flask C, while still attached to the ringstand, is introduced through a slot into a large cardboard cylinder. Around the arm supporting flask C, is packed sufficient cotton to close the opening in the cylinder. The agar medium in the flask is kept at about 45° C. by means of an electric bulb placed inside the cylinder. D and E are again connected. When the apparatus has cooled sufficiently, the rubber stopper is removed from flask D, the seeds and the desired disinfectant are quickly introduced, and the flask is again closed tightly. Flask D is then thoroughly shaken, so that the disinfectant may come in intimate contact with the walls of the flask, the tube and the rubber stopper. This is to destroy any spores that may have happened to enter when the flask was opened to admit the seeds and disinfectant. When the seeds have been in the disinfectant the required length of time, the disinfectant is drawn off into the cistern E, by means of tube c. The last drops can readily be removed by tilting flask D. Water is then drawn through cock B from flask A into flask D, upon the seeds. This is done by exhausting the air in cistern E. To prevent the air from entering flask D during this process, a rubber finger-cot can be drawn over b″ or the finger may simply be pressed down on it. In that way the seeds can be washed as frequently as desired. After washing them, some of the agar medium is drawn from flask C by turning cock B so as to connect C and D. Agar solidifies at 42° C. It is therefore kept at about 45° C until needed. That temperature will not harm the fungi or bacteria that may adhere to the seeds. Sufficient agar to cover the seeds is introduced. The rubber tubes between D and B and between D and E are closed by means of clamps. The rubber tubes are cut beyond the clamps and flask D is ready to be set aside to incubate.

In all of the following germination experiments, all of the seeds were carefully inspected so as to obtain only perfect specimens. In all the germination experiments, each lot consisted of twenty-five seeds. The germination percentage, under ordinary laboratory conditions, of the seeds in the following experiments was as follows: *Lupine* 96%, *Pea* 96%, *Wheat* 96%, *Corn* 100%, *Mustard* 96%. The first agent used in treating the seeds was cleaning fluid ($H_2SO_4+K_2Cr_2O_7$). As far as I have been able to ascertain it has not been employed for the purpose before. It occurred to me that cleaning fluid might be a very desirable agent to use since it penetrates no farther than it thoroughly oxidizes. Thus, by timing its action, we can destroy as much of the seed-coat as is safe under any given conditions, and also the adhering fungus

TESTING APPARATUS.

and bacteria spores, even such fungus hyphae as may have penetrated part way into the seed-coat. From what I knew of the properties of cleaning fluid, I had no idea that any seeds were so resistant to its action. For instance, *Lupine* immersed in it for five hours and fifteen minutes still gave 52% of good seedlings. Up to about two hours immersion *Lupines* gave in practically every case, about 100%, of good seedlings. *Peas* were also more resistant than was expected. After six minutes exposure, 88% of good seedlings were obtained; and after forty-five minutes immersion, the yield was still 76%. *Wheat* was found to be rather sensitive to the action of cleaning fluid. After seven minutes exposure it yielded only 28% of good seedlings. *Corn* was found to be more resistant than *Wheat* but not so resistant as *Lupines* or *Peas*. After seventeen minutes exposure, 88% of good seedlings of *Corn* were obtained; but from there on the percentage of germination fell rapidly. Thus, after twenty minutes exposure, only 16% of good seedlings were obtained and, after twenty-five minutes exposure only 4%. *Mustard* was slightly more resistant than *Wheat*. After a ten minutes exposure, 56% of good seedlings were obtained.

The second disinfectant employed was mercuric chloride. To prevent the adhesion or air-bubbles to the seeds, or a thin layer of air, the seeds were first dipped in 70% alcohol, then thoroughly rinsed in water to remove the alcohol and finally placed in the mercuric chloride. The concentration of mercuric chloride employed varied from one gram of mercuric chloride in one thousand cc. of water to one gram in fifteen cc. of water. When *Lupines* were immersed in a one to two hundred and fifty solution for fifty minutes, 100% of good seedlings were still obtained. Beyond that concentration and length of immersion the percentage steadily decreased, until, at a concentration of one to fifteen for one hour and fifteen minutes it had dropped to 52%. For *Peas* a one to five hundred solution only was used. The yield of good seedlings, after a thirty minute immersion was 88%; and after a fifty minute immersion it was 64%. Wheat was found to be much more sensitive to mercuric chloride than either *Lupines* or *Peas*. After a thirty-minute immersion in a one to five-hundred solution, only 52% of good seedlings were obtained; while after an immersion of ten minutes, the yield was 92%. *Corn* was found to be more resistant to the action of mercuric chloride than *Wheat*. After an immersion of thirty minutes in a one to five-hundred solution, the yield of good seedlings was 68%; but, in a one to two-hundred and fifty solution, after the same length of time, the yield was only 20%. *Mustard*, after an immersion of ten minutes, in a one to one thousand solution yielded 76% of good seedlings. When the concentration was increased to one to five hundred and the time to thirty minutes, the percentage dropped to eight. Before planting in the germinator, the seeds were thoroughly washed in several changes of water for about an hour.

The third disinfectant employed was potassium dichromate. The concentrations employed varied from N / 2 to N / 1000; and the length of immersion varied from fifteen minutes to an hour. As in the case of the other disinfectants, the yield of *Lupine* was relatively high, since the yield was still 84% after an immersion of one hour in an N / 2 solution. The highest concentration found practicable, in the case of *Peas*

was N / 50. After being immersed in this for an hour, the yield was 72%. The same concentration could be used for *Wheat*. After a twenty minute immersion, the yield was 88%. The concentration most useful in the case of *Corn* was found to be N / 10. The yield after an immersion of one hour, was still 56%. N / 25 was better adapted to *Mustard* than any other concentration. After a twenty minute immersion, the yield of good seedlings was 88%.

The last disinfectant used was formaldehyde gas. Forty per cent formaldehyde was put in an open vessel placed on a glass plate, on which the seeds were also placed. The whole was then covered with a bell-jar, the edge of which, where it came in contact with the glass plate, was given a coat of vaseline so as to make the chamber air-tight. Both dry seeds and seeds soaked for five minutes in water were used. The dry seeds of *Lupine* had to be exposed for an hour and forty-five minutes before the germination percentage dropped; and then it had dropped only to ninety-six. When the soaked seeds had been exposed for forty-five minutes, the germination percentage dropped to ninety-two. Beyond these periods, the vitality of the seeds steadily decreased, that of the soaked seeds becoming zero after seven hours, while the dry seeds retained their vitality an hour or two longer. The relative effect of the gas on dry and wet seeds is clearly brought out in the case of *Pea*. Dry seeds, exposed for fifteen minutes yielded 64% of good seedlings; while the soaked seeds yielded only 28%. To obtain a yield of 64% in the case of the wet seeds, they could be exposed for two minutes only. After a twenty-five minute exposure of the wet seeds, only 16% of good seedlings were obtained; while the dry seeds, exposed for an hour, still yielded 36%. *Wheat* was found to be less sensitive to formaldehyde than *Peas*. After an exposure of fifteen minutes, the dry seeds yielded 92% of good seedlings; while the soaked seeds still yielded 52%. A ten-minute exposure of the wet seeds, also gave 92%. The dry seeds of *Corn* were considerably more resistant than *Wheat*; the soaked seeds only slightly so. Dry seeds, exposed for an hour, yielded 80% of good seedlings, while wet seeds, exposed for thirty minutes, yielded only 36%. The dry seeds of *Mustard* could be exposed three times as long as the soaked seeds, and they still showed an equal vitality. Thus dry seeds exposed for forty-five minutes, and soaked seeds, exposed for fifteen minutes, both yielded 40% of good seedlings. Dry seeds, exposed for thirty minutes, yielded 68%; while wet seeds, exposed for the same length of time, yielded only 24%.

In the first column of Table I are given the names of the seeds; in the second column the disinfectants; in the third column, the concentrations best suited for the different kinds of seeds; in the fourth column, the length of immersion of the seeds in the disinfectants which would still give a fair percentage of good seedlings; in the fifth column the germination percentage and in the sixth column are given the results, as tested with the apparatus (see plate), of the action of the different disinfectants on the fungi and bacteria on the seeds. As can be seen by running over this column, only five lots out of twenty-five were found to be sterile, each lot being treated differently.

TABLE I.

Seed.	Disinfectant.	Concentration.	Time.	Per cent good seedlings.	Result.
Lupine	Cleaning fluid	Full strength	3 hours, 45 min.	68	Sterile.
Pea	Cleaning fluid	Full strength	10 minutes	68	2 Sp. Fungi.
Wheat	Cleaning fluid	Full strength	3 minutes	76	1 Sp. Fungi.
Corn	Cleaning fluid	Full strength	15 minutes	76	1 Sp. Fungi.
Mustard	Cleaning fluid	Full strength	8 minutes	72	Sterile.
Lupine	Mercuric Chloride	1–15	1 hour	72	Sterile.
Pea	Mercuric Chloride	1–500	30 minutes	72	Bacteria.
Wheat	Mercuric Chloride	1–500	15 minutes	80	Sterile.
Corn	Mercuric Chloride	1–500	20 minutes	68	Sterile.
Mustard	Mercuric Chloride	1–1000	10 minutes	76	Bacteria.
Lupine	Pot. Dichromate	N/2	1 hour	84	Bacteria.
Pea	Pot. Dichromate	N/50	30 minutes	80	Bacteria; 1 Sp. Fungi.
Wheat	Pot. Dichromate	N/50	20 minutes	88	1 Sp. Fungi.
Corn	Pot. Dichromate	N/10	30 minutes	72	1 Sp. Fungi.
Mustard	Pot. Dichromate	N/25	20 minutes	96	Bacteria; 1 Sp. Fungi.
	Seeds dry.				
Lupine	Formaldehyde gas.	40 % formalin	4 hours	72	1 Sp. Fungi.
Pea	Formaldehyde gas.	40 % formalin	15 minutes	64	Bacteria.
Wheat	Formaldehyde gas.	40 % formalin	30 minutes	72	Bacteria.
Corn	Formaldehyde gas.	40 % formalin	30 minutes	64	1 Sp. Fungi.
Mustard	Formaldehyde gas.	40 % formalin	30 minutes	68	Bacteria.
	Seeds Wet.				
Lupine	Formaldehyde gas.	40 % formalin	2 hours	72	Bacteria.
Pea	Formaldehyde gas.	40 % formalin	1 minute	72	Bacteria.
Wheat	Formaldehyde gas.	40 % formalin	10 minutes	92	Bacteria.
Corn	Formaldehyde gas.	40 % formalin	15 minutes	50	1 Fungus.
Mustard	Formaldehyde gas.	40 % formalin	5 miuutes	80	Bacteria.

I was not at all certain that the five lots, which showed no contamination in the foregoing experiments, would show the same results again, if treated in a similar manner. For this purpose three lots of each were set up and allowed to incubate. The results are given in Table II. Three of the five failed to show up sterile three times in succession, while two did. That means that apparently only two lots out of the original twenty-five could be depended upon as being sterile when treated according to Table I. Of these two lots, one was Lupine and the other was Mustard.

TABLE II.

Seed.	Disinfectant.	Concentration.	Time.	First lot.	Second lot.	Third lot.
Lupine	Cleaning fluid	Full strength	3 hours, 45 min.	Sterile	Sterile	Sterile.
Mustard	Cleaning fluid	Full strength	8 minutes	Sterile	Sterile	Sterile.
Lupine	Mercuric Chloride	1–15	1 hour	Sterile	Bacteria	Bacteria.
Wheat	Mercuric Chloride	1–500	15 minutes	Sterile	Bacteria	Sterile.
Corn	Mercuric Chloride	1–500	20 minutes	Sterile	Sterile	Fungus.

Since the decisive failure to obtain sterile seeds, shown in Tables I and II, might reasonably be expected to make the technique appear open to criticism, to say the least, it was thought advisable to set up a set of control cultures by means of the apparatus. After the apparatus had been sterilized in the autoclave, it was attached to the aspirator and

air was drawn through the filter plugs for at least five minutes to test them and at the same time test the rubber connections. No seeds or disinfectant were placed in D. Water was then drawn from flask A into flask D, shaken up, and again drawn off. This was done several times, just as when there were seeds in flask D. Flask D was then taken out and set aside to incubate, as in the experimental cases. The idea was to test the apparatus by using it as nearly as possible in the same way as when seeds and disinfectants were present. As a matter of fact, I took less pains in the control experiments to see that the joints were perfectly tight than I did when I tested seeds. The fact that flask D was not opened during these control experiments cannot be held as an objection, since any chance contamination, when the seeds were placed in flask D, is reached by shaking up the disinfectant so as to thoroughly reach every part that might have become contaminated. If the chance spores were able to survive that, then it is manifestly impossible to kill those on the seeds, and the point is proven either way. The only place the disinfectant, when the seeds are treated, does not reach is the inside of the small glass tube connecting B and D. It was sterile when D was opened to admit the seeds and disinfectant and during the brief period of time that D remained open the mouth of the tube was directed downward, so no spores could drop in and none could be drawn in, since there was no draft into it. Besides, if any contamination could come from this source, in the case of the seeds, it would have appeared in the control as well. Yet none of the controls showed any contamination. The conclusion seems irresistible that the contamination must have come from the seeds. It was thought that twenty controls were an ample number.

The foregoing work has convinced me that the results of formerly published work are open to criticism in at least two respects: No adequate proof is given that the seeds are really free from contaminating organisms and no means are employed to so thoroughly remove the disinfectant that it could no longer act as a antiseptic. In view of the foregoing results, we are forced to conclude that the majority of cases of so-called disinfection were merely cases of antisepsis.

To antisepsis, and not to disinfection, we must probably look for practical results. It makes no difference in physiological experimentation whether a few dormant organisms cling to the seedling or not. what does the harm is their active growth and multiplication. Absolute disinfection, which seems out of the question at present, is not essential.

E. Lansing, April, 1910.

COMPARISON OF WARM vs. COLD HOUSES AS REGARDS EGG PRODUCTION.

H. L. KEMPSTER.

It was generally supposed that a poultry house should be warm, and houses were constructed double-walled to keep the birds comfortable. Whether this was necessary has been one of the problems we have endeavored to determine. With this idea in mind, three experimental houses were built, 14x24, large enough to accommodate 70 laying hens. No. 1 was double-walled, having a four inch air space in walls and ceiled above. No. 2 was double-walled on the north side, and east end. No. 3 was single boarded. For two years comparison records were kept. During the first year, November to April:

1.....2,850 eggs.
2.....3,128 "
3.....3,022 "

This shows a production of 172 eggs in 3 over No. 1, and also a production of 278 more eggs in 2 than in 1. It also shows a production of 106 more eggs in 2 than in 3.

The second year, December to March:

1.....2,540 eggs.
2.....2,379 "
3.....2,334 "

This shows a production of 206 more eggs in 1 than in 3 and also a production of 45 more eggs in 2 than in 3. It also shows a production of 161 more eggs in 1 than in 2.

For the two years:

1.....5,390 eggs.
2.....5,507 "
3.....5,356 "

The stock kept was White Leghorn, 70 in each pen, and care was exercised so that the quality was the same in each house. As a result of the two years test, No. 2, or the house double-walled on two sides, showed a production of 151 eggs over No. 3 which was single walled, and also, 117 over No. 1 which was double-walled. No. 1 produced only 34 eggs more than No. 3. There is not enough difference in the three houses to permit the justification of a double-walled house. Beyond the supply of comfort to the birds, additional expense in the way of double walls is unnecessary. A poultry house should be dry, free from drafts, and well lighted, and ventilated. When we have secured those conditions, other factors must be taken into consideration when it comes to egg production.

E. Lansing, Mich., April 1910.

PLANT EXCRETION.

J. B. DANDENO.

By excretion is meant the process involved in the setting aside of useless or harmful products, either within or without the cells of the tissue concerned. In a general way, the excretory products of plants are found in one or more of the following places: (1) in intercellular spaces, (2) in vacuoles of cells, (3) in cells from which all other content has been withdrawn, (4) on the outside entirely of the plant, (5) in glands. Excretory products may occur (1) as liquid in glands or in the vacuoles of cells, (2) as solids (crystals), (3) as gases set free from the walls of the cells of living tissues.

The metabolism of plants is so complicated and so variable that a great variety of forms of excretory products is to be expected, depending on the character of the plant, and upon the external and internal conditions. The character of the plant is the chief factor in deciding as to what the substance of the excretion may be. The external conditions have to do more particularly with the location of the excretory substance.

The matter of excretion in short-lived plants like Spirogyra, Pleurococcus, etc., is exceedingly simple, the product being attracted from the vacuole by the surrounding water, if the vacuole itself is insufficient to contain it. In the case of long-lived plants, such as trees, the process becomes much more complicated, and at the same time a matter of more importance. But the tree has several means, in a general way, by which the process of excretion is carried on. These are the dead cells, corky bark, leaves (which are only temporary structures and consequently are lost sooner or later carrying with them the excretion), mycorrhiza which feed upon the excretions made by rootlets of long lived trees and shrubs, glandular structures and surfaces.

The functions of excretions if they have any, must be more or less indirect, as for example, in the cases of poisonous or malodorous substances which upon occasion serve the purpose of protection against certain enemies. Resin, which is thought to be an excretion, may prove of advantage to the plant upon the occasion of mechanical injury, acting as an antiseptic to the wound.

Several other substances which are claimed to be absolutely essential to the plant are supposed by some to be primarily excretory. Take for instance, the cellulose cell wall. Some very low forms of plant life are devoid of a cellulose wall, and it does no violence to our ideas of the cell to suppose that cellulose being no longer of use in the metabolism of the protoplast was deposited laterally and externally as a wall, this wall proving at the same time to be useful in protecting the cell against several injurious conditions, e. g. loss of water. This is probably an extreme view, but it illustrates the point. If the cell wall be an excretory product, this is a case where the excretion becomes not only important but of essential importance.

One of the most common excretory products found in higher plants is calcium oxalate, which assumes quite a variety of crystalline forms varying from the needle-shaped bodies known as raphides, to the large star-pointed bodies found in cactus stems. Calcium oxalate crystals are located in various places in the plant, most frequently, in empty cells of the cortex or in the neighborhood of vascular bundles in leaves. Some of the largest are found in intercellular spaces as for example in gladiolus bulbs where they develop so large as to be seen with the unaided eye.

Calcium carbonate occurs occasionally in plant cells but is found most frequently on the epidermal structures in the neighborhood of water-pores. It is often so abundant as to cover a very considerable area of the leaf surface around the pore. Calcium sulphate is also occasionally found in crystalline form and often associated with calcium carbonate. Many of the drug products on the market are without any doubt products of excretion by the plant, but it is not the intention here to go into this matter further than to mention the facts as they bear upon the discussion of the forms of excretion in roots and leaves. It is these forms of excretion to which special attention has been given and concerning which data has been collected for this paper.

Excretion from roots: The present view as to the nature of the substances excreted by roots may be expressed in the following quotation:[1] "The principal substances diffusing from roots are mainly CO_2 passing out as H_2CO_3, phosphoric, hydrochloric, sulphuric and formic acids and their salts, preeminently substances which would aid the plant to obtain needed food materials from the soil."

It has long been known, and it is easily proved, that CO_2 is liberated from roots in the processes of growth and of vital activity, but so far as I am aware, no one has ever proved definitely, or claimed to have proved, that organic matter like glucose, or saccharose is excreted by plant roots. Carbon dioxide is a natural product of aerobic respiration and consequently it is easy to see that CO_2 would be liberated from actively growing roots, and that in very considerable quantity. But it is somewhat surprising to find glucose and similar substances excreted. To prove this is not difficult. Young seedlings when grown in distilled water or upon moist filter paper give out comparatively large quantities of such substances, which soon become infested by aquatic or other fungi and by enormous numbers of bacteria. Intermingled with this glucose material are the waste cells of the root cap which, no doubt, contribute to the quantity or bulk of the excretion but which can be seen as distinct from it.

When the mass of material is heated, it gives off the odor of burning sugar and later turns brown and black. If heating is carried on further, then the mass is burned down to ash, which proves to be composed of patassum and calcium, mainly, but may also contain other metals. This syrupy mass adhering to the root tip gives a distinct alkaline reaction to litmus test paper. It might be said in this connection, that litmus paper usually becomes very distinctly red, when lying around the laboratory for a long time and such paper should be held over an ammonia bottle until it is nearly neutral. Paper so treated shows a very quick

[1]Plant Physiology, Peirce, p. 126.

and positive alkaline reaction. Now it is not easy to see how such excretion could contain hydrochloric, sulphuric, formic acid, etc. It may be, however, that some of these substances develop as result of bacterial decomposition in connection with the soil but in the case of a medium of distilled water, and of a duration of 18 to 24 hours, there is very little chance for extensive bacterial action.

The root excretion is so constant in occurrence and reaction with seedlings that the conclusion seems warranted that such excretion is a normal function of roots of seedlings possessing a supply of stored food. Whether this function is general with rootlets of plants past the seedling stage, we are not yet prepared to say. Further investigation is needed. At all events, so far as we have gone, it seems to be true of plants well advanced in growth, but the amount of excretion is much less. This is especially so with respect to the organic portion of the excretion.

How such a function can be of advantage to a plant is not easy to see, nor is it easy to see how it can result otherwise than as a distinct loss of what appears to be organized plant food. And yet, in looking closely into the matter, we are led to the conclusion that such is inevitable especially in seedlings. The seedling has as yet no excretory tissue, no dead cells in which to store up excretion, and excretions are a necessary result of the metabolism involved in growth. The root tip, including about ten or fifteen mm. from the end, is actively growing. Highly organized material is being reduced and unless it be on the outside of the plant there is no place for excretions. Since the conducting tissues are not yet developed, the excretions are necessarily found near the place of active growth. Consequently it is not surprising after all, to find organic matter located as excretion substance near the root tip —the region of most active growth.

The excretion soon becomes attacked by fungi and bacteria which further reduce it, so that it becomes slightly acid, due partly to the presence of carbon dioxide. The mycorrhiza fungi gain their start upon the host plant here, and to such plants as are symbionts with mycorrhiza, there is no doubt that the excretion serves a purpose by furnishing a nutrient medium suitable to the rapid development of fungus hyphae. Such fungus hyphae finding a supply of nutritive material in solution in connection with the loose cells near the root cap penetrate into such loose tissue and remain attached to or embedded in the rootlet. Later on the hyphae of the fungus absorb water and unorganized substances in solution from the soil and transfer it to the host.

Actively growing fungi excrete substances which may react upon the soil particles, setting free or bringing into solution useful inorganic matter. Bacteria often serve a similar function and bacteria are often, if not always, found in the root excreta after a day or two. Excretions of bacteria often react upon the soil and in fact, these organisms are perhaps the most important agents in rendering unorganized soil material into a soluble form which may then be available to plants.

Now, the root hairs of plants are located a short distance, a few centimeters, from the root tip, and as the root makes its way through the soil, the root hairs follow after the tip and would therefore be in a position to profit to the best advantage by any material made available

by fungus hyphae or bacteria which had begun to use the substance excreted at or near the tip. We can therefore, see how, what seems to be a waste substance, may prove of great advantage to a plant, and that at a time of life when great demands are soon to be made upon nutrient soil solutions.

Excretions from leaves: During times of high activity in plants, excretions occur upon leaves as a result of checked transpiration accompanied by normal absorption. During the day time, in land plants provided with stomata a great deal of water is transpired in the form of water vapor. During the night root activity is as great as in the day time and transpiration is reduced. The plant is provided with a mechanism to relieve the pressure by excreting liquid matter. The chief part of this mechanism is the water-pore, the morphological equivalent of the stomate, though not its physiological equivalent. Stomates are essentially organs concerned with transfer of gases. Water-pores are concerned with the transfer of water (or solutions). A water-pore is therefore, a sort of safety value and is very common among higher plants.

Solutions exuding from water-pores are found to contain organic and inorganic matter. If these drops of solution fall to the ground, as they sometimes do, the plant loses substance to the soil. If conditions be favorable, much of this material may be resorbed through the water-pores and taken in again into the cells of the neighboring tissues. If the external air be dry it will cause a rapid evaporation of the drops of excretion substance, and an incrustation will be formed in the region in the neighborhood of the water-pore. Such incrustations may be seen on wheat, oats, barley and the like, on the tips of the leaves. In broad leafed plants, they are found, on the margin near the ends of the veins of the leaves. In most cases these incrustations are very soluble in water and are soon washed off, but in some of the xerophytic plants, where lime is abundant, the incrustations are somewhat permanent. This is notably the case with certain saxifrages.

Whether the function of excretion from leaves is of advantage to the plant has not yet been proved, but it is thought that, in view of the common occurrence, it is likely to be of some advantage. At all events, where the excreted liquid matter is washed down to the soil, it is likely to affect that soil to a certain extent. A study of soil fertility must, therefore, include a consideration of leaf excreta.

Leaf excretions bear an important relation to the effect of fungicides such as Bordeaux. They react upon Bordeaux rendering some of the copper soluble and thus making the Bordeaux more toxic, often so much so as to kill the leaves in the neighborhood of the waterpores, which are situated at the margin of the leaf.

But the water-pores are not the only means of excretion in leaves. Excretion may occur through the epidermal cells of leaves having little or no cutin. This can be proved by applying distilled water to the surface. In nature, rain water extracts substances through the surface. This is concerned also with the application of fungicides or insecticides. what is insoluble in the spray liquid may become soluble through the reaction of the liquid drawn from the cells of the leaf.

The explanation of the process of excretion involves the process of

attractions of solute and solution, whether it be in connection with root or with leaf. An understanding of the mechanism of the plant cell and of the relations existing between solute and solutions is necessary to an appreciation of the situation. The older theories of osmosis are inadequate to the explanation of these phenomena as well as to those relating to the production of nectaries.

The importance of fungus excretions may be inferred by giving a very prominent instance to illustrate it: Many of us have seen the Fairy Ring mushroom growing in lawns or pastures. This fungus has a peculiar effect upon the growth of grass associated with it. At this (spring) time of the year, the grass on the lawn is likely to be twice as long where the mushroom mycelium lies than it is elsewhere. The color of the grass is of a deeper green and the ring becomes larger (of greater diameter) year by year. A study of the matter reveals the fact that the fungus excreta aids very materially in rendering available the inorganic material—to be organized later—into plant food. This association is decidedly favorable to the grass.

The two chief conclusions developed out of the discussion here given and of the experiments relative to it are: (1) Roots (of seedlings especially) excrete a liquid rich in organic matter, which is alkaline in reaction at least for three or four days after excretion. (2) Leaves excrete (generally in the form of dew) both organic and inorganic matter, and also, to a certain extent, both organic and inorganic matters are washed out of leaves by rain.

East Lansing, Mich., Apr. 20, 1910.

FURTHER OBSERVATIONS ON THE LIFE HISTORY OF PUCCINIA MALVACEARUM.

J. B. DANDENO.

This subject was worked over rather thoroughly by us some years ago, and the result published in the 9th Report of the Michigan Academy of Science, 1907, but further observations on this fungus since that time, seem to us to warrant a brief review with the addition of such facts as have developed since then.

As this rust has but one so-called stage—the teleuto stage—in its life cycle; and as the teleuto spores germinate immediately upon reaching maturity, the question of the wintering over has been one feature most prominently of interest. It is with regard to the wintering over, from year to year, that further observations led me to present this brief paper before the Academy.

This rust seems to be distinctly on the increase in our locality, but this need give no alarm for the reason that the plants likely to be infested by the fungus, are of little economic importance. In fact, if we leave out of consideration the ornamental plant, Hollyhock, we might say of no economic importance. The common mallow of gardens and waste places around yards and buildings is generally considered something of a noxious weed, and this is the plant most commonly affected. The rust, however, is likely to infest other plants of the mallow family, particularly the following genera including: Malva, Althaea, Malvastrum, Sidalcea, Malope, and Abutilon. The following genera, though growing side by side in the Botanic Garden at the College, were free from the disease: Anoda, Hibiscus, Napaea and Sida.

A few of the species of those genera mentioned above as susceptible to the disease, are considered of value as ornamental plants, especially in the east, consequently the rust is of some importance from the economic side, and it would seem to be worth while to make some effort toward checking it. This will be suggested in the life history here given.

Life History: The spores germinate immediately, i. e., without any period of rest, producing a promycelium on which are developed a few sporidia (promycelial spores). This takes about two or three days. The sporidia also germinate as soon as mature and send out an infective mycelium which, under suitable conditions, enters a stomate of the leaf, petiole, or stem of the host. In about seven or eight days after infection, a new sorus appears, and in about ten days mature teleuto spores are developed. Consequently, about two weeks is required in artificial infection to complete the life cycle. This cycle of reinfection goes on,—weather conditions being favorable,—the whole growing season. And, for the common mallow, Malva rotundifolia, this is from March to December. With us in Michigan, the common mallow is a perennial and the fungus winters over in this plant. We have been able to find this rust every month in the year, around old buildings and in sheltered places on the south side. After a few fine sunny days,

sori develop from the dormant mycelium in the stems and petioles. It winters over with the common mallow, and if the common mallow be eradicated, it is our opinion that the disease would be practically under control.

Some authors assert that the teleuto spores winter over and thus carry the disease from year to year. This is clearly not the case here. The teleuto spores germinate as soon as mature, therefore it would be practically impossible to keep them dormant during the winter. If they did germinate, the sporidia would at once die. Moreover the first appearance in earliest spring is on the stems and petioles, the youngest leaves being free. This shows that the infection is already in the plant remaining dormant during frost and developing during fine weather.

The teleuto spores germinate in the sorus,—producing a grayish appearance while the ungerminated are of a clear amber-brown color. The Promycelium grows in a direction parallel with that of the pedicil of the teleuto spore, so that they project out in all directions from the sorus, and it is our opinion that these sporidia are the means of infection, that is to say, they and not the teleuto spores, are carried from place to place. This may be inferred from the fact that the teleuto spores germinate "*in situ*." We infer, also, that infection can not take place at very great distances, because the sporidia are delicate bodies and will not stand dry air for any great length of time. This feature is something which in itself would prevent wide spread infection. It does spread, no doubt, but slowly. Seedling mallows out in garden or orchard are usually not affected at all, until very late in the season. The rust can always be found where the mallow grows in uncultivated ground perennially.

To combat the disease, eradicate all the old mallows in the fall.

In my paper before this Academy in 1907, it was stated that the fungus wintered over in the mallow. We are now more firmly convinced than ever of this. In this connection it might be worth while to say that one or two facts were brought out during the discussion following the paper, namely that the rust wintered over on the Hollyhocks around Ann Arbor, and that in the neighborhood of St. Louis, Mo., it was common on *Hibiscus* while *Abutilon* appeared to be free from the rust. The writer assumes no responsibility for these statements, although the authority is doubtless reliable.

East Lansing, Mich., April 1910.

SODIUM SILICATE AS A MOUNTING MEDIUM.

J. B. DANDENO.

For the past five years, off and on, we have used sodium silicate as a convenient medium for mounting fresh specimens of various kinds, and, for certain purposes, it has proved very useful. Sodium silicate, sometimes called soluble glass, has been used as a cement for crockery and glassware, and more recently also as a preservative of eggs,—the sodium silicate being spread over the surface of the shell as a glazing.

As a medium for mounting histological preparations, sodium silicate was suggested to us by Prof. Kedzie a few years ago and brought to our laboratory by a former student, Mr. Loew. In our laboratory, we often run across accidentally, sometimes through students, sometimes in our own work, specimens which show certain things particularly well, and it is often desirable that such should be kept permanently. This occurs more frequently in investigating fungi or fungous diseases of plants. Glycerine and balsam are practically the only permanent mounting media now in use, and glycerine is a very poor affair, because it never solidifies; and in handling, the cover glass is likely to be moved and very frequently the specimen destroyed. Glycerine mounts *can be* kept permanently but they have to be ringed with a suitable material, and even then, a considerable proportion is sure to be destroyed. With regard to balsam, the work of dehydration and preparation is so long, that a specimen would be almost certainly lost in the process.

It is here where sodium silicate comes in, as it mixes perfectly with water and hardens in a day or two, so that, if one happens upon a few spores of this, a few asci of that, or of any other particularly desirable structure, he can, by the addition of a drop of sodium silicate, preserve the specimen indefinitely. This substance does not mix well with glycerine or alcohol and must be used with water. It can be put on the specimen either by removing the cover glass and placing the drop in the ordinary way, or by drawing a drop under the cover. The former is the more satisfactory unless there is danger of losing the specimen in lifting the cover.

Sodium silicate has some advantages and some disadvantages which shall be pointed out:

Advantages:—(1) It is convenient, always ready, and makes permanent specimens directly from water. (2) Its optical qualities render it one of the very best known, as its index of refraction is nearly the same as glass. (3) It is slightly alkaline in reaction and does not shrink or plasmolyze fresh material, in some cases preserving even the color

Disadvantages:—(1) If the objective of the microscope becomes smeared (accidentally of course) with it, and if left so for a few days, the objective is spoiled, as the silicate unites with the glass of the objective. If, however, it be cleaned right away, and especially with a drop of diluted hydrochloric acid, no harm is done. (2) It tends to become whitish around the edge of the cover in a few years and looks bad and

in this connection it should be said that air bubbles are likely to develop here and there under the cover if the silicate has been made too dilute by the water already on the specimen in mounting. (3) Once mounted and hardened, the cover and slide are fixed together and can never be cleaned again. (4) In mounting with this material, air bubbles are more likely to be mixed in than is the case with either balsam or glycerine.

It is not the intention here to suggest that sodium silicate replace either balsam, glycerine or any other of the standard substances, but rather to introduce it as a useful addition to our mounting equipment, for fresh or undehydrated specimens.

East Lansing, Mich., April 1910.

THE DISTRIBUTION OF MUSHROOMS AT NEGAUNEE, MICHIGAN.

ROSE M. TAYLOR.

During the summer of 1909, it was the pleasure of the writer to do some work collecting Mushrooms in the vicinity of Negaunee, Michigan, under the direction of Dr. C. H. Kauffman. This work was carried on during the months of July and August. It rained almost continuously the first two weeks of July and at frequent intervals from that time on, until the end of August. Thus, conditions were unusually favorable for the growth of Fungi. Altho a few Ascomycetes were identified, the collecting was confined to the Hymenomycetes only.

My thanks are due to Dr. E. R. Downing of the Marquette Northern Normal for the generous use of his laboratory and the Normal library.

After making several excursions to the principal woods around Negaunee, three definite regions,—because of their diversity of elevation, woods, and moisture,—were selected as the chief collecting grounds. These regions may be designated (1) The Iron Cliff Region, (2) The Deer Lake Region, and (3) Mud Lake Region.

First, the Iron Cliff Region, which lies to the southwest of Negaunee and about a mile distant from the city, is characterized by a succession of very high hills, with intervening valleys traversed by small streams or often by swampy ravines. These hills enclose a low plain, dotted with a chain of numerous small lakes which are fed by the streams from the surrounding region. A road winds in and out among the hills and covers a distance of about six miles. The slopes are densely clothed with a virgin forest of hardwoods, such as, Poplar, Hard Maple, White Birch, Ash, and a few Oaks. Here and there are a few clumps of conifers. The side hills and ravines are strewn with moist and rotted logs. During moist weather, the higher ground proved the better collecting place while the swamps and ravines were the more fruitful in dry weather.

Both Agaricaceae and Polyporaceae are common to this region. On the higher slopes, where there is little debris and the woods are more open, one finds different species of Cantherellus, Flammula, Clytocybe, and Entoloma. Among these are also a few unreported species of Naucoria, Nolanea, and Hypholoma. Along the roadside and in the more open places of the lower slopes, several species of Coprinus grow in profusion. Here too, Mycenae and a few species of Pleurotus are thick on old logs of maple and birch. In the lower ravines Pholiotae are numerous on logs and sometimes at the base of live maple trees. This entire region is marked by a scarcity of Lactarii, Amanitae, Russulae and Cortinarii. Among the Polyporaceae,—several species of Fomes, Polyporus, Polystictus, and Gleosporus are abundant. The Clavariaceae are very common on the rotted logs in the ravines and on the lower slopes, but do not appear until August.

The second Region mentioned, Deer Lake, lies to the northeast of Ne-

gaunee about three miles. It is about two miles north of Ishpeming and is actually included in its township. The lake is small, about two miles in length, and occupies a low depression surrounded by wooded hills. The western slope is especially well wooded,—covering an area of about three miles and descends to a strip of lowlands, which slopes gently to the lake below. The eastern part of this lowland is a swampy ravine traversed by a little creek. This swamp is densely wooded by a second growth of Conifers consisting of tamarack, hemlock, fir-balsam, and a few hardwoods. The ground is covered with dead logs and pine needles. The western portion of this lowland is higher, not wooded, and quite dry. The higher slopes are well wooded with hardwood of the same type as those around the Iron Cliff Region and some conifers. This region, because of its variation in elevation, light, and moisture, over a small area,— is an ideal place for the mushroom hunter. Several species of Cortinarius are abundant under the conifers on the slopes, and are especially common in the cedar swamp. The same variety of Fungi, common to the higher slopes of the Iron Cliff Region, are here in greater abundance. In addition, the higher slopes abound in several species of Amanitopsis, but there is a scarcity of Coprinii, Hygrophori, and Entolomae,—so common to the former region. The following species, unreported for this state, are numerous:—Clitocybe cerussata, Lactarius luteola, and Psilocybe canofaciens. About the middle of August, different species Agaricus appear on these higher slopes. After a slight rain fall, the western and higher part of the lowland is thickly covered with unusually large specimens of Boleti, Lactarii, and Russulae. The more swampy eastern part of the lowland teems with species of Clitocybe and Tricholoma.

The third region, Mud Lake, is about two miles east of Negaunee. The topography of this region is similar to that of the Deer Lake region, except that the hills are higher and descend very abruptly to the lake below. The slopes are well wooded with hardwood. A little stream with very steep banks winds around the hills and feeds the lake. These slopes are characterized by the same kind of Fungi that are common to the two other regions mentioned above. On the higher ground, along the road and in the more open places, several species of Amanitae are very large and abundant. This genus was not found in the other two regions. Here also, the Lactarii and Russulae are very numerous.

In all three regions, the Polyporaceae are more abundant on logs or stumps on the higher slopes not too densely wooded with hardwood. Here also are found such genera as, Armillaria, Collybia, Cantherellus, Entoloma, Hygrophorus, Hypholoma, Lentinus, Leptonia, Mycena, Nolanea, Schizophyllum, Tricholoma, and Volvaria. On the lower slopes and in more open places, the following genera are abundant:—Agaricus, Amanita, Amanitopsis, Boletus, Coprinus, Clitocybe, Flammula Lactarius, Lepiota, Pholiota, Pleurotus, Russula. The Cortanarii seems to be found under conifers and are especially abundant in cedar swamps or ravines wooded with hemlocks. As a rule, the higher places, not too thickly wooded, are more favorable for the growth of Fungi than low swampy ground.

East Lansing, Mich., April 1910.

PLANTS NEW TO MICHIGAN.

S. ALEXANDER.

Chelone obliqua L. Red turtle head. There is a small plantation of this plant immediately beyond the north side of the right-of-way of the Michigan Central R. R. Co., and on the west side of the Huron river where it is first crossed by the M. C. R. R. east of Ann Arbor. There were several other small plantations on the island, a little above the point described but they have been destroyed by the Park Commission of Ann Arbor as have many other rare and valuable plants.

Coralorhiza multiflora florida Peck. This plant grows in the forest on the Cranbrook farm, two and one-half miles northwest of Birmingham.

Physalis macrophysa Ryd. Found at the foot of the hill northeast of Dr. Newcomb's house on the way to the U. of M. botanical garden. Said by Britton to be rare in Texas, Arkansas and Kansas, its most northerly known limit heretofore.

Aster furcatus Burgess. Found on the south side of the river Raisin, about twenty rods below the bridge where the Ann Arbor R. R. crosses that river at Dundee.

The two species first mentioned were reported by me to Professor Beal several years ago. They were overlooked and not put in the last edition of the "Michigan Flora" as they should have been.

Ann Arbor, Mich., April 1910.

NOTES ON THE YELLOW ADDER'S-TONGUE.

O. A. FARWELL.

Presumably, most botanists have been at one time or another, rather disappointed, to say the least, at not being able to find a rare or interesting plant that the manuals have accredited to the districts over which they have collected; especially if they have made special but unsuccessful efforts to find it. One such plant, a form of the yellow adder's-tongue, occurs to the writer. It had been diligently sought for years but unsuccessfully. At last, it was found in abundance, in the spring of 1908, when the writer was on his annual vacation and collecting trip. In places, the plant literally covers the ground with a carpet of its mottled leaves. It is found in abundance in the vicinity of Lake Linden, Houghton county, in the Upper Peninsula of Michigan. In the 5th edition of Gray's Manual, it is mentioned under E. albidum, as follows: "At Lake Superior, Dr. Robbins finds a plant like this but *yellow-flowered*, a transition toward E. Grandiflorum." This form has not been mentioned in subsequent editions. A careful examination of many hundreds of individuals showed that the plant is probably an aberrant form of E. Americanum rather than of E. albidum. It had the mottled leaves, the corm, the united stigmas and the spotted petals of the former, differing from it only in the teething of the inner petals. A careful study of these showed that the species was still in a stage of transition. The inner petals varied as regards the toothing, and could be found in all stages, from the usual tooth on each side at the base, to the perfectly toothless form, as in E. albidum. Some petals showed the teeth much shortened, so that they were only one-half or one-quarter, etc., as long as the normal; some were toothed on one side only, while in the same flower one of the inner petals might be normally two-toothed, another toothless, and the other showing some intermediate stage. The extreme forms, that is, the normally toothed inner petals on the one hand and the toothless inner petals on the other, were not as common as the intermediate stages.

Does this form occur at other places? and if not, why not? So far as the writer has been able to ascertain, this form has not been reported from other localities. He has not found it in Lower Michigan where the ordinary form is rather common. E. albidum occurs in the Lake Superior district and its origin as a hybridization product has suggested itself; but a very careful study has not revealed any strain of E. albidum in the form under discussion.

The form needs further study.

May 2, 1910.

UNREPORTED MICHIGAN FUNGI FOR 1909.

C. H. KAUFFMAN.

Through the efforts of Dr. L. H. Pennington, it is possible to include in this year's report a list of the Myxomycetes of the state. The herbarium of the University was made the depository of quite a series of Ann Arbor slime moulds, collected and studied by Prof. V. M. Spalding and his instructor, Miss Fanny E. Langdon, during the years 1885 to 1895. Their collections were examined and verified or identified in many cases by Prof. McBride, as noted in the list. L. N. Johnson and A. J. Pieters were also active during this period in adding specimens to this collection. In recent years Dr. Pennington made a considerable collection and has materially increased the number already in the herbarium. He also examined and verified the list given below.

The species of the other groups reported in this paper were collected in various parts of the state. The dry season at Ann Arbor produced a scanty crop of fungi, but this was offset by the moister conditions in the Northern Peninsula. Miss Rose M. Taylor, located at Negaunee, sent a large number of specimens collected in that vicinity, and from these and my own collections from the same place later in the summer, a number of plants new to the state, were obtained and are listed here.

MYXOMYCETES.

Phytomyxiniae.

Plasmodiophora brassicae Woronin. Jour. Myc. Vol. 7, p. 79.

Exosporeae.

Ceratiomyxa fruticulosa (Muell.) Macbr. Very common on decaying sticks.

Myxogastres.

Physaraceae.

Fuligo ovata (Schaeff.) Macbr. Common everywhere on decaying refuse and rotten wood.

Fuligo violacea Pers. Ann Arbor. (In herb. of Pennington.) Fide L. H. P.

Physarum ellipsosporum Rost. On decaying straw. Ann Arbor. Fide L. H. P.

Physarum contextum Pers. Ann Arbor. (In herb. Pennington.) Fide L. H. P.

Physarum diderma Rost. Reported from Michigan by Macbride.

Physarum cinereum (Batsch.) Pers. On grass, campus, Ann Arbor Fide L. H. P.

Physarum nefroideum Rost. Upon laboratory cultures, etc. Fide Macbr.

Physarum globuliferum (Bull.) Pers. Ann Arbor. (In herb. Pennington.) Fide L. H. P.

Physarum leucopus Link. Lenawee Co. (In herb. Pennington.) Fide L. H. P.
Physarum rubiginosum Fr. Ann Arbor. Fide L. H. P.
Tilmodoche viridis (Bull.) Sacc. Ann Arbor. Fide L. H. P.
Badhamia orbiculata Rex. Ann Arbor. Fide L. H. P.
Badhamia papaveracea Berk. & Rav. (In herb. Johnson at North West. Univ).
Craterium leucocephalum (Pers.) Dit. Houghton and Ann Arbor. Fide L. H. P.
Cienkowskia reticulata (A. & S.) Rost. Ann Arbor. Fide Spalding.
Mucilago spongiosa (Leys.) Morg. On decaying leaves and living stems of herbaceous plants. Ann Arbor, etc. Fide L. H. P.
Didymium minus Lister. On dead leaves. Ann Arbor. Fide L. H. P.
Didymium squamulosum (A. & S.) Fr. Ann Arbor. Fide Spalding.
Didymium xanthopus (Dit.) Fr. On moss. Ann Arbor. Fide L. H. P.
Diderma spumarioides Fr. Ann Arbor. Fide L. H. P.
Diderma crustaceum Pk. Lenawee Co. Fide L. H. P.
Diderma testaceum Schrad. (Pers.) On dead leaves. Ann Arbor. Fide L. H. P.
Diderma niveum (Rost.) Macbr. On artificial cultures in laboratory. Fide Macbr.
Diderma hemisphericum (Bull.) Horne. On moss. Ann Arbor. Fide L. H. P.
Diderma floriforme (Bull.) Pers. On decayed logs. Ann Arbor. Fide L. H. P.

Stemonitaceae.

Amaurochaete fuliginosa (Sow.) Macbr. Ann Arbor. Fide L. H. P.
Stemonitis fusca (Roth) Rost. Ann Arbor. Fide A. J. Pieters.
Stemonitis Morgani Pk. Ann Arbor. Fide Macbr.
Stemonitis axifera (Bull.) Macbr. Whitmore Lake, Washtenaw Co. Fide Macbr.
Stemonitis Smithii Macbr. Ann Arbor. Fide Macbr.
Comatricha laxa Rost. Ann Arbor. (In herb. Pennington.) Fide L. H. P.
Comatricha nigra (Pers.) Schroet. Ann Arbor. Fide L. N. Johnson.
Comatricha longa Pk. Ann Arbor. Fide Spalding.
Diachea splendens Pk. Ann Arbor. Fide Spalding.
Lamproderma violaceum (Fr.) Rost. Ann Arbor. (In herb. Pennington.) Fide L. H. P.

Cribariaceae.

Reticularia lycoperdon. Bull. Ann Arbor. Fide L. H. P.
Enteridium splendens Morg. Ann Arbor. Fide L. H. P.
Enteridium olivaceum Ehren. Ann Arbor. Fide L. N. Johnson.
Dictydiaethalium plumbeum (Schum.) Rost. Fide L. H. P.
Lindbladia effusa (Ehr.) Rost. Ann Arbor. Fide L. H. P.
Tubifera ferruginosa (Batsch.) Macbr. Ann Arbor. Fide L. H. P.
Tubifera stipitata (Berk & Rav.) Macbr. Ann Arbor. Fide Macbr.
Dictydium cancellatum (Batsch.) Macbr. Ann Arbor. Fide Spalding.
Lycogola epidendron (Buxb.) Fr. Very common. Fide L. H. P.
Lycogola flavo-fuscum (Ehr.) Rost. Upon maple trunks. Ann Arbor. Fide L. H. P.

Trichiaceae.

Perichaena corticalis (Batsch.) Rost. Ann Arbor. Fide L. N. Johnson.
Lachnobolus occidentalis Macbr. Ann Arbor. Fide L. H. P.
Arcyria nutans (Bull.) Fr. Very common. Fide L. H. P.
Arcyria incarnata Pers. Ann Arbor. Fide Macbr.
Arcyria denudata (Linn.) Shel. Very common. Fide L. H. P.
Arcyria cinerea (Bull.) Fr. Common. Fide L. H. P.
Arcyria digitata (Schw.) Rost. Ann Arbor. Fide L. H. P.
Hemitrichia serpula (Scop.) Rost. Ann Arbor. Fide L. H. P.
Hemitrichia clavata (Pers.) Rost. Very common. Fide L. H. P.
Hemitrichia stipata (Schw.) Macbr. Ann Arbor. Fide Macbr.
Trichia contorta (Didm.) Rost. Ann Arbor. Fide Macbr.
Trichia varia (Pers.) Rost. Ann Arbor. Fide Spalding.
Trichia scabra Rost. Ann Arbor. Fide Spalding.
Trichia persimilis Karst. Ann Arbor. Fide Macbr.
Trichia favoginea (Batsch.) Pers. Common. Fide Macbr.
Trichia botrytis Pers. Ann Arbor. Fide L. N. Johnson.
Trichia decipiens (Pers.) Macbr. Ann Arbor. Fide Macbr.
Trichia inconspicua Rost. Ann Arbor. Fide Macbr.

ASCOMYCETES.

Geoglossaceae.

Cudonia lutea (Pk.) Sacc. On moist ground. Marquette Co. Aug. 10. Fide C. H. K.

Helvellaceae.

Helvella infula Schaeff. On the ground, in woods of spruce, cedar, white birch, etc. Ishpeming, Marquette Co., Aug. 21. Fide C. H. K.

Pyronemaceae.

Pyronema omphaloides Bull. On burnt ground. Washtenaw Co., May 15. Fide C. H. K.

Pezizaceae.

Galactinia saniosa Schrad. On moist ground, mixed woods. Marquette Co., Aug. 21. Fide C. H. K.
Otidea leporina (Batsch) Fuckl. Ground, mixed woods. Presque Isle, Marquette Co. Aug. 27. Fide C. H. K.

Helotiaceae.

Arachnopeziza aurelia (Pers.) Fuckl. (Syn. Belonidium aurelia (Pers.) DeNot.) On old logs. Washtenaw Co., May 15. Fide Durand.
Arachnopeziza delicatulum Fuckl. On rotten wood. Washtenaw Co., June 5. Fide C. H. K.
Dasychypha subtilissima (Cke.) Sacc. On decaying branches. Washtenaw Co., June 12. Fide C. H. K.
Dasychypha Willkomii Hartig. On fallen twigs of Larix, in tamarack bog. Washtenaw Co., June 3. Fide C. H. K.
Helotium fraternum Pk. On petioles of Acer, in woods. Marquette Co., Aug. 23. Fide C. H. K.
Pilocratera abnormis sp. nov. Pk. in ed. On decorticated logs. Ishpeming, Marquette Co., Aug. 21. Fide Pk.

Phacidiaceae.

Rhytisma acerinum (Pers.) Fr. On leaves of Acer rubrum in bog. Washtenaw Co., June 3. Fide C. H. K.

Hypocreaceae.

Hypomyces aurantia (Pers.) Fuckl. On decaying Polyporus frondosus. Washtenaw Co., Nov. 1907. Fide Pk.

Cordyceps entomorrhiza (Dicks) Fr. On pupa, woods of Palmer Park, Detroit, June 5. Fide C. H. K.

BASIDIOMYCETES.

Dacryomycetaceae.

Guepinia palmiceps B. & C. Palmyra, Lenawee Co. (In herb. Pennington.) Fide Pk.

Thelephoraceae.

Thelephora palmata Fr. Ground, oak woods. Monroe Co., July 26. Fide C. H. K.

Thelephora Willeyi Clinton. Ground. Lenawee Co., July 26. Fide C. H. K.

Hydnaceae.

Hydnum velatum B. & C. Washtenaw Co. (In herb. L. H. P.) Fide Pk.

Polyporaceae.

Polyporus rutilans Fr. On dead branches, rather common. Washtenaw Co. Fide Atkinson and Pk.

Polystictus barbatulus Fr. On dead branches. Marquette Co., July. Fide C. H. K.

Agaricaceae.

Amanita chlorinosma Pk. Ground. Wayne Co., Oct. 19. Fide C. H. K.

Clitocybe cerussata Fr. Ground in woods. Marquette Co., Aug. 10. Fide C. H. K.

Collybia stridula Fr. Ground, in cult. fields. Washtenaw Co., June 7. Fide C. H. K. Probably often confused with Tricholoma melaleucum.

Deconica subviscida Pk. Among grass in pastures. Washtenaw Co., June 9. Fide C. H. K.

Flamula fusa (Batsch) Fr. On rotten stumps. Washtenaw Co., June 9. Fide C. H. K.

Flamula gummosa (Lasch.) Fr. On rotten wood in cedar swamp. Marquette Co., Aug. 24. Fide C. H. K.

Hygrophorus niveus Fr. Ground. Marquette Co., Aug. 27. Fide C. H. K.

Inocybe hystrix Fr. On ground, conifer woods. Presque Isle, Marquette Co., Aug. 7. Fide C. H. K.

Lactarius affinis Pk. On ground, mixed woods. Marquette Co., Aug. 21. Fide C. H. K.

Lactarius colorascens Pk. Low grounds, mixed woods. Marquette Co., Aug. 21. Fide C. H. K.

Lactarius luteolus Pk. Low ground. Marquette Co., Aug. 21. Fide C. H. K.

Lactarius piperatus Fr. var. fragrans Burlingham. (Certainly a definite variety.) Ground, mixed woods. Presque Isle, Marquette Co., Aug. 21. Fide C. H. K.

Lactarius turpis Fr. Ground, conifer woods. Presque Isle, Marquette Co., Aug. 27. Fide C. H. K. In every respect like the Swedish plant.

Lentinus haematopus Berk. On dead wood. Marquette Co., Aug. 21. Fide Pk. (A single specimen, in Peck's herb.)

Marasmius semihirtipes Pk. Among grass and twigs, fence rows. Washtenaw Co., May 30. Fide C. H. K.

Pleurotus lignatilis Fr. On logs, elm, maple, etc., woods, Aug. 4, 1905. Fide C. H. K.

Pluteus caloceps Atk. On the ground. Dead Lake, Washtenaw Co., Oct. 15, 1904. Fide Atkinson. (Reported by Atkinson in Ann. Mycol. Vol. 7).

Pluteus cervinus Fr. var. albus Pk. Marquette Co., July 28. Fide C. H. K.

Pluteus salicinus (Pers.) Fr. On very rotten wood, in swamp of willow, etc., July 27. Fide C. H. K.

Pholiota aggericola Pk. Ground in low woods. Emmet and Houghton Co., 1905-6. Fide C. H. K.

Psilocybe canofaciens Cooke. Negaunee, Marquette Co., Aug. 10. Fide C. H. K.

Psilocybe submaculata Atk. (See Ann. Mycol. Vol. 7), where it is described and reported from Michigan).

Tricholoma rancidulum Banning. Ground in woods. Washtenaw Co., Sept. 14, 1907. Fide C. H. K.

Tricholoma venenata Atk. Poisonous. Rochester, Oakland Co. (Description, etc., published in *Botanical Gazette,* Vol. 46., 1908, page 461 by Atkinson).

University of Michigan, May 1910.

ANOTHER OBSERVATION ON SCLEROTINIA FRUCTIGENA.

JAS. B. POLLOCK.

The question as to whether the brown rot fungus of the stone fruits, Sclerotinia fructigena, produces its ascocarps more than a year after the mummied fruits have fallen from the tree has up to the present been an open one. When Norton in 1902 discovered the ascocarps of this species, he believed that they grew from mummied fruits which had lain under ground two years, but this could not be demonstrated. An opportunity has been presented to the writer to make the demonstation that this fungus does produce ascocarps the second season after the mummied fruits have fallen from the tree. In the spring of 1909, on ground belonging to the Botanical Garden of the University of Michigan, a group of plum trees was cut down before the leaves came out. In preceding years these trees had borne regular crops of fruit, a portion of which was always attacked by the brown rot fungus, Sclerotinia fructigena. The ground on which these trees stood was not cultivated and the mummied plums had fallen in the grass under them for years, some of them being covered with earth through the action of earth worms and the washing action of rain. No other plum trees stood within thirty rods of the trees under consideration, and the conditions were thus favorable for determining the question whether the mummied plums, or rather the sclerotia contained in them, would develop the cup-like ascocarps more than two years after they had fallen from the tree. In 1909 a good collection of the ascocarps was made where the plum trees had stood, and again in 1910. The apothecia were growing directly from the old mummied plums, which had fallen from the trees not later than 1908. This demonstrates that two-year-old mummies are capable of developing ascocarps. Reade reports that in his work on Sclerotinia he obtained the apothecia in about a year in artificial cultures.

In another species, Sclerotinia aestivalis, which the writer described in the Michigan Academy Report for 1909, mummied apples collected in the summer of 1908 produced ascocarps all through the summer of 1908, and after standing over winter dry in the laboratory in covered glass dishes which had served for moist chambers, the same mummied apples produced another crop of apothecia in April 1910. The second crop was decidedly smaller in size than the first one of the preceding summer. It developed after the apples had again been moistened, and kept in the moist chamber.

It is certain then that not only can sclerotia of Sclerotinia produce ascocarps two years after the sclerotia were first formed, but also that in at least one species of Sclerotinia the same sclerotium can produce two crops of ascocarps. Whether the last statement is true of Sclerotinia fructigena we do not know, but it seems not improbable. The ability to produce ascocarps the second year whether they are the first or second crop from a given sclerotium, must be of considerable im-

portance for the persistence of the fungus in a locality where the mummied fruits are not destroyed. If the weather for one season were so unfavorable for the fungus that no plums rotted and hence no new sclerotia were formed, the old mummies would still carry the fungus over to the next season, and we do not know that even two years is the final limit beyond which the fungus cannot reproduce itself. The importance of destroying the old mummied fruits, whether on the ground or on the tree, is manifest. E. F. Smith long ago pointed out that the mummies which hang on the tree from one season to the next are often capable of producing a new crop of conidia in the spring.

Univ. of Michigan, April 1910.

INCREASED COST OF LIVING.

THE SITUATION.

Wilbur O. Hedrick.

The subject of our discussion is one which in a very practical sense might be conceived as of that kind to which the older economists so frequently alluded as things concerning which "everyone had a notion sufficiently correct for common purposes." But not unlike many of the other terms thus undiscriminatingly disposed of the expression "increased cost of living," must be given more definite boundaries in order to be useful for discussion.

The popular presentation of the subject which has filled so many columns of our newspapers and magazines during the past winter, if not indeed during the past decade, has seldom undertaken any close discriminations as to the meaning of "cost of living." The apparently unanswerable argument which has been used to support the contention of an increased "cost of living" has been a table of statistics which show that the prices of most commodities are higher now than was formerly the case. These grim looking statistical tables—resembling not a little both in subject matter and in general associations the display boards which stand before restaurants—would indeed be incontestable proofs if there were national households anywhere which, without having had bettered incomes, were obliged to pay these prices. But there are of course no such households and when it is remembered that "cost of living" to have any practical significance must have reference to actual private households the assumed sequence of high prices being followed by inevitably high costs is badly shaken. A skillful imagination for example might easily picture such an arrangement of occupations as would allow each to enjoy high prices and yet the interdependency among these occupations might be such that none of the members of any of them would be either better or worse off through the price situation. Abstinences and economies of all sorts are also resources which are much relied upon by households to keep down the cost of living in the face of high prices and have thus prevented the need of "deficit financiering" in the family budget which would otherwise exist. Common observation shows that some classes benefit from the high prices which are paid and the result is that there is no such universal identity between the two terms as the newspaper and magazine headlines would lead us to suppose.

The cost of living has been one of the greatest concerns to mankind from the beginning and economists have always recognized its importance. It was the cause for example of some of the great migrations and it is at present at the bottom of the colonial policies of nations like Japan, Germany and England. In its harshest aspect it is Darwin's "struggle for existence," and Malthus relied upon it as the force which would keep human population in abeyance. Our contemporary conservation of resources movement takes root in the fear that "mankind

may starve at last" through the exhaustion of natural resources—a fear which has been ministered to by the dire forbodings of Sir William Crooks, Mr. J. J. Hill, Mr. Pinchot and others—while tariff controversys resound with the claims and counter claims in behalf of the "ultimate consumer."

It is preeminently a practical question to the economist and its influence upon economic theory also is manifest when we remember that such important laws as those of diminishing utility, of diminishing returns and of substitution would become almost insignificant if detached from their relation to the "cost of living."

Curiously enough the provocation which has stirred the agitation of the day concerning "cost of living"—namely, high prices—is nowhere regarded by economists as of serious importance in comparison with some of the other causes which have been suggested. The subject of high prices in most of the economic text books is found in connection with the treatment of money and the explanation from Prof. Laughlin "that he who sells goods for more money (that is for higher prices) will have to pay more for the goods he buys and is no better off than where there was less money"[1] typifies fairly well it will be found the attitude of most economic writers toward high prices.

The term "cost of living" itself when approached for purposes of definition is found to be without significance except as it has reference to sacrifice. Most studies upon this subject, indeed, like the one completed by Prof. Chapin last year or the one carried on by the United States Bureau of Labor in 1903 have given equal emphasis to the matter of income as to the matter of expenditure. The family is the customary object of investigation in determining costs of living because it is a social unit with such interdependencies among its members that all alike are affected by changes in the scale of living and it is the household budget which reflects the constituents which enter into this outlay. The very flexible but imperative body of wants and acquirements which goes by the name of standard of living must also be reckoned with in any thorough going study of wealth consumption. Whether we take the scale of living which Congress intimated last year was the suitable one for our chief magistrate or the one which John Mitchell has drawn up as fitting for the unskilled laborer or any intermediates for our model it will still be found that "the standard of living" is the real determinate of the satisfactoriness or the unsatisfactoriness of our state with regard to cost of living. As another has well said "actual privations are not necessary to create a sense of economic disadvantage; mere thwarted hopes are amply sufficient."

Whatever may ultimately be established as to the relations between increased "cost of living" and "high prices" the reality of this latter condition seems assured and the facts with regard to high prices remain now to be examined. In an able treatise upon wealth distribution written by the late Charles Spahr the belief is expressed "that in matters concerning which they are interested the common observations of common people is more trustworthy than the statistical investigations of the most unprejudiced experts," and that "social statistics are only trust-

[1]Elements of Economics, p. 78.

worthy when they show to the world at large what common observation shows to those personally familiar with the conditions described."[1]

It is very properly my task then, though at the risk of some circumlocution, to confirm common observation by showing statistically the changes which the prices of household goods are undergoing, and this undertaking is all the more readily assumed through the fact that commodity prices have been very carefully arranged to form the well known price tables or index numbers. The elaboration of these tables has been the work of years under such names as those of Mulhall, Palgrave, Mitchell, Bradstreet, Dunn, Sauerbeck and Sootbier and a respectable literature has been developed concerning the choice of averages, the commodities to be chosen, the use of weights and the selection of base years.

The avowed purpose of these price tables or index numbers is to reflect the movement of prices—to show the averages of the marginal comparisons between money and commodities which have been made within a given time, and, for this purpose, many considerations are involved which only remotely affect the cost of living. It is true indeed that in a broad sense all the products of man's labor are intended for consumption and, in an immediate or remote way, enter into the expenses of living, but, as we have seen, the term "cost of living" to have a useful meaning must refer to the cost of real things to real households and the cost of living to a people would be the aggregated expenses of these budgets. Under these circumstances production goods of all sorts and lands and mines, forests and fisheries since they never are found in family budgets should be excluded in a technical sense from consideration. The problem of selection which separates the commodities which enter into cost of production from those which do not is also an important problem in the construction of price tables or index numbers. It is obvious at once that in arranging a price table, which shall show the average of prices among a people during a given period, that observation of all the ratios of exchange which have been made is humanly impossible. No single commodity can have all its measurements in terms of money recorded nor can all the commodities even in a single place. Under these circumstances certain typical commodities must be chosen and their most typical prices made use of in arranging the average.

It is this matter of the commodities which have been chosen and the prices which have been utilized which makes some of these tables more acceptable in showing the high prices of household goods than are others. This difference may be easily illustrated. Sootbier for example found the statistics available in the Hamburg customs house and board of trade records for ascertaining the prices of nearly one hundred and forty-four articles over a period of thirty-eight years from which to compute his index numbers. In 1885 Hamburg became a free port and his records ceased. It is apparent that availability alone determined largely in this instance the commodities which were chosen.

In contrast with this rather superficial basis for price collection, the United States Senate table of relative prices for the 1840-1891 period grouped and weighted commodities according to the proportions in which they entered into household expenses and greatly enlarged the number of commodities upon which observations were made.

[1]Distribution of Wealth, Chas. Spahr, preface.

This Senate table was discontinued early in the nineties and its successor so far as the government is concerned is the table of the Bureau of Labor which I have used for the price movements of this paper.

The Bureau of Labor has made use of the retail prices of 30 and the wholesale prices of 250 staple commodities, has collected them for nearly ten years and shows plainly by its tabulations that the alarming rise of prices recently experienced is merely the prolongations of an upward trend of a dozen or more years.

The upward trend of the retail prices of 30 ordinary table food commodities as collected by the government in 67 different places and from 1,105 different dealers is as follows: 1901 index numbers 105.½ points; 1902, 110.9; 1903, 110.9; 1904, 111.6; 1905, 112.5; 1906, 116.2; and 1907, 120.7 a total rise of 15.2 points in six years. It is also significant that each and every one of the 30 commodities save sugar alone had a higher price in 1907 than in 1901.

Turning now from the commodities which merely minister to the table and noticing the other family living expenses we find here a lapse in the governmentally collected retail prices and consequently wholesale rates must of necessity be considered. The Bureau of Labor has tabulated these wholesale prices since 1901 for the extraordinarily large number of 250 commodities the most of which it has grouped under the following significant heads—Foods, etc., 57 articles; cloths and clothing, 44 articles; fuel and lighting, 13 articles; drugs and chemicals, 9 articles; house furnishings, 14 articles and lumber and building materials, 28 articles. It will be recalled from memories of the family budget that most of the constituents of the material side of living group themselves naturally under one or the other of the titles which have just been read so that the relative prices of these different groups from year to year should show significantly how living expenses have risen. Further than this they correspond closely with the headings under which the familiar commodity consumption statistics of our text books are collected and this confirms us in the belief that these goods appertain to living.

The retail prices of 30 food products as we have just seen appreciated 15.2 points in six years. The appreciation of 57 such products at wholesale rates during six years was not so great varying from 105.9 in 1901 to 117.8 in 1907. During the same period the cloth and clothing group increased from an index number of 101 in 1901 to 116.9 in 1907 or a gain of 15.9 points. Three articles alone of this group, it should be mentioned, hosiery, covert cloth overcoatings and Wamsutta shirtings became cheaper during the progress of this period than they were at its beginning. The thirteen members of the fuel and lighting group appreciated from 119.5 in 1901 to 130.8 in 1908—a rise of 11.3 points; lumber and building materials as represented by 28 articles moved up 16.4 points and the 14 articles of house furnishings rose 13 points, while drugs and chemicals alone of all the household essentials have steadily declined in price during the decade selling for nearly five points less in 1908 than in 1901.

In addition to this rather matter of fact record of the heightened prices which nearly all the household essentials have recently had, this report of the labor bureau affords still another way of showing the same outcome. This is through the differentiation of the prices of consump-

tion—fit goods from the prices of goods still in their raw or unmanufactured state. The classification of commodities into those which are primary and into those which are derivative is a familiar one in our economic text books and it is a useful arrangement here because it enables us to go back beyond the 160 or more articles—all derivative goods—whose index numbers have just been noticed and examine the prices of the raw materials—vegetable, animal or mineral—out of which they were made.

The table of the bureau considers 200 derivative or manufactured articles—namely the ones we have already just considered and shows a rise in points of their index number from 107.8 in 1901 to 122.2 in 1908—a total of 14.1. On the other hand fifty new commodities—the primary goods—or those which are marketed as raw materials—show a rise during the same period from 111.4 in 1901 to 125.5 in 1908, an increase of 14.1 points. It is along this line of inquiry it may be noted that if the statistics were available and we wished to push our derivatives far enough, the prices of natural agents and of production goods, which we rejected in an earlier part of the paper, would produce their proper effect upon the cost of living.

From still another standpoint the situation with regard to high prices may be shown from data which the bureau of labor has collected. This is from the standpoint of relative total money expenses of a family at present as compared with the preceding decade. In its study of the living expenses of 2,567 families in 1901, the bureau of labor ascertained a normal rule of expenditure for different household needs, and, assuming that this is typical for other families and that it has not varied until the present time the information is easily at hand for showing the growth in the family budget so far as food is concerned.

In 1901 expenditures for food from one family equalled roundly $325; 1902, $345; 1903, $343; 1904, $347; 1905, $349; 1906, $359; and in 1907, $375 an increase of $50 in six years.

Again from the standpoint of the "distance a dollar will go" in buying food products the labor bureau's report shows that 7 lbs. of fresh beef could be secured for this sum in 1901 or 9¼ lbs. of salt beef; 8 lbs. of fresh pork, the same of salt pork; 7¼ lbs. of chicken; 7 to 10 pounds of fish; 5 doz. of eggs; 16⅔ qts. of milk; 4 lbs. of butter; 6 lbs. of cheese; 9 lbs. of lard; two of tea; 4⅓ of coffee; 16¾ sugar; 2 gal. of molasses; 40 lbs. of flour; 43½ lbs. of corn meal; 20⅓ lbs. of bread; 12¼ lbs. of rice and 1 bush. of potatoes. At no time during the succeeding six years—as an average throughout the year—would a dollar purchase as much of any one of these commodities as the amount we have just described save in the case for one year of lard and for all years of sugar and coffee.

Finally with regard to all prices everywhere both foreign and domestic and of all commodities the index number of the London Economist shows a gradual appreciation as follows: 1896, 61 points; 1906, 77 points and 1907, 80 points—exceptions being made in this instance also of the prices of sugar, coffee and tea.

More specifically it may be interesting to note that the February report of the Canadian Department of Labor tabulated retail price quotations upon thirty-three articles of food collected from all the cities of

the dominion for the date of January 1910, and the records show an almost undeviating correspondence with the prices of similar articles in this country.

The distributive effects of high prices in apportioning incomes to the various members of the economic classes are much less capable of accurate exposition than is the fact itself of high prices. Within the field of the economic shares statistical inquiry has not been so successful as with prices and our most perfectly recorded investigations of any of these shares—namely the census reports concerning land rentals—are now a full decade removed. Under these circumstances no resource remains apparently save that of common observation for the explanation of the class results which have issued from high prices.

Of all the economic classes which have benefited from this situation, the profit receiver has doubtless fared best. Looking behind the rows of figures which represent the money value of our yearly product of manufactured commodities—a row which has now become far too long for intelligent comprehension—and we see newly built factories and business blocks, recently opened mines and improved transportation facilities on every hand as the substantial evidences of the existence of profits. The external transformation and enlargement which has overtaken the financial and business center of the land—New York City—within the the last decade—a change which a recent visitor, Mr. H. G. Wells, declares "found this city of brown stone the color of dessicated chocolate and will leave it of white and colored marble" speaks eloquently of the prevalence of business profits. In the not infrequent view of a real profit which a newspaper reader gets through the disbursements of dividends on the part of some large concern, one sees nothing to dissuade him from the belief that business men find prosperity in high prices.

A special class of profit receivers, the farmers, has apparently enjoyed especial benefits from high prices during the latter part of this decade. "Most prosperous of all years is the place to which 1909 is entitled in agriculture" is the opening sentence in the report from the Secretary of Agriculture for 1909. The money value to which the farm crops of last year was entitled exceeded 8¾ billions of dollars—an amount almost exactly twice as large as that of eleven years ago. The recent overspreading of the Canadian Northwest by the American farmer of the west and middle west may be attributed to high prices in two ways. First, it has been made profitable to open these distant lands. Second, they have made the rental price of the home land almost prohibitively high to the would-be purchasers. The products of this region should by right of logic apparently be added to the aggregates which the secretary of agriculture has made for the American farmer.

The attempts to discriminate the tone or spirit of an industry as a basis for judging its prosperity may seem to many the very climax in the use of the observational method. Nevertheless, there are many evidences which support the belief that a more prosperous air pervades agriculture than was formerly the case.

The agricultural discussions of the decade which closed with the Industrial Commission of 1901, for example, and even the expert testimonies which were given to this commission had much to say of the ills of the farmer. The underlying note of all these discussions is the

farmer's discontent and the character of the alleviation which should be applied. One will look in vain through the newspaper and magazine articles upon agriculture during the recent years for a gloomy note concerning this industry. We read, on the contrary, titles concerning the "New American Farmer," the "New Spirit of the Farm," "Seven and a Half Billions from the Farm," etc., etc., as testimonies concerning the new standing of this vocation.

Few indeed of the manifold activities of our late great executive were more widely censured on account of needlessness than was the appointment of the Rural Life Commission when it was thought that the purpose of this investigation was to discuss the impoverishment or waning prosperity of our farming class.

A single small observation which has come within my own experience may serve as a slight straw to show the prosperous trend of agriculture. I refer to the increasing popularity of technical training in this pursuit to the young industrialists of the land. I think no one has failed to notice a certain relationship between the prosperity of an industry and the schools which minister to that industry. The industrial awakening of the early part of the decade for example stimulated engineering schools everywhere. The conservation movement which followed a few years later gave forestry schools a period of wide popularity, and other instances might easily be recalled. In conformity, I believe with this connection between occupational prosperity and professional school prosperity the fact of agricultural profitableness is shown by the high tide in point of numbers which technical courses in agriculture have everywhere recently attained.

An allusion was made a moment ago to the newspaper and magazine proofs of the thriftiness of the farming class, but no one will consult authority of this sort without having his attention called to evidence pointing in the other direction in regard to that class of persons who draw salaries. The significance of this situation with regard to salaries which are suffering from halting or fully arrested development is apparent when we accept the popular belief that economic society is undergoing a transformation from the leadership of the small but independent business man to that of the salaried official, in the large concern.

Another industrial class which has seemingly benefited but little from the prevalence of high prices is the money lending capitalist. Reasoning here from the flimsiest of analogies, one concludes that if half the earnings which were attributed to these Wall Street people during the low price period of the nineties were really received by them then, the reversal of their income situation through the present high prices must be extreme indeed.

By an outright usurpation of the point of view possibly, or else as a species of tribute to the sovereignty of the profit variety of income in our economic organization, we have accustomed ourselves to the practice of identifying "good times" with high prices and "bad times" with a low level of exchange ratios. Whether the strain upon this tradition is as near or not the breaking point as the public press would have us believe, we have had at any rate a great public excitement over high prices. In his annual message of last fall, President Taft called atten-

tion to this price phenomena. In the early winter both houses of Congress, several state governments and many semi-public organizations undertook the study of the upward trend of prices. Many other organizations—mostly of laboring men—without waiting for help from investigation, undertook to apply a remedy through boycotts or other sorts of force. The high level of prices afford a situation which is, we may readily concede, a proper field for governmental investigation, even though we doubt the availability of remedies to government—and much more so to the belligerent private organizations—even after the cause of the disorder is discovered. In the meantime, there seems to have been little or no decline in prices, and the ill effects from this situation are so wide spread that any explanatory information seems sure of a cordial reception from the waiting public.

Mich. Agricultural College, April 1910.

CAUSES AND REMEDIES AS SEEN IN MONETARY CONDITIONS.

JAS. E. MITCHELL.

We are accustomed, as a people, to work up a great deal of emotion over slight or evanescent ills. Nor are we alone in this. We remember how England, but a few months ago, was stirred up over what was imagined to be a threatened invasion by Germany.

The present high prices, in my judgment, are not a cause for serious alarm. To be sure some of our medical friends say we are in danger of degeneration from under nutrition, but if the truth were told we should be found to be in much greater danger of degeneration from excessively extravagant living.

Our present prices seem extreme in contrast with the abnormally low prices of—say thirteen or fourteen years ago. This is especially true of certain food-stuffs, notably meats and some other farm products, which are indeed very high, but the reasons for this will, no doubt, be explained by others.

Our Democratic brethren persisted, back in 1896, in telling us that gold had been steadily increasing in value for more than twenty years; that the dollar would purchase more products, the world over, in '96 than at any time during this period. They told our farmers that their products had diminished in value relatively to gold; that it took more of the products of the farm to pay the mortgages they had contracted in previous years than the money they had borrowed would purchase of those same products at the time the mortgages were given. In other words, they told the farmers, whose long time debts were coming due, that they would have to pay back more than they had borrowed—not more money, but more value, more purchasing power.

All this was, in large measure, true and hard for their Republican opponents to satisfactorily answer. For whether we view the general price level in the period from 1882 to 1896 from the standpoint of wholesale or retail prices, from that of raw materials or manufactured products, or whether we compare the trend of prices in the United States with that of foreign countries, a decided decline in prices is noticeable.

This is graphically illustrated in various United States bulletins. In the chart here exhibited—which is an enlarged copy of one taken from the report of the United States Industrial Commission vol. XIX—we have the comparative movement of wholesale prices in this country and Great Britain, from 1882 to 1901. We note a fall in the United States of 45 points—from 120 to 75—or 38% ; and in Great Britain of 31 points —from 109 to 78—or 28% ; that is, 62 cents would purchase as much in this country in 1896 as $1.00 in 1882; and the equivalent of 72 cents in English money would buy as much in Great Britain in 1896 as the equivalent of a dollar would in 1882.

This is only another way of saying that gold increased in value, during that period of fourteen years, about 62% in the United States, and about 40% in Great Britain. Before the present rise in prices, therefore, there was a very remarkable fall.

No wonder the Democratic orators waxed eloquent over the sufferings of the debtor class. But they went too far, and essayed to prophesy. They told us these same conditions were going to continue, under the gold standard, and be intensified; that gold would still farther increase in value, and that for the simple but sufficient reason that there was not enough gold in the world to do the money-work and supply what was needed in the arts. Of course they proved to be poor prophets, as the subsequent gold output and present high prices clearly demonstrate.

According to Bradstreet's index number prices have advanced in the United States up to January 1st, 1910, about 62%—have just about recovered the previous loss. A dollar in 1896 would, therefore, buy as much as $1.62 at the present time—which is the same as saying that 62 cents would buy as much then as a dollar now.

In England the advance in prices to the level of the early eighties has not been quite so complete. Industry, in Great Britain, has been slow to recover from the panic of 1907, due probably to the agitation over the budget question. Prices have risen in England, however, according to Sauerbeck's and the London Economist's index numbers about 30%. In other foreign countries they have increased from 30% to 40%, and under normal conditions in England they no doubt would have increased to the same extent.

I have corresponded with careful observers of economic conditions, in England, stating to them the rise in prices here and asking whether they had advanced in the same degree there. One answered, "Not quite to the same extent but almost;" another wrote, "Not quite so much;" a third was unable to give the per cent of advance but attributed it to the increased output of gold.

Opinions gathered from such sources are of course not conclusive; nor indeed is data gathered from any source absolutely final. But from the best that can be obtained it seems reasonably certain that there has been a common increase of from 30% to 40%. Local conditions make it much more in the United States and considerable more in some foreign countries.

Undoubtedly in no country has the advance been due to a single cause. Economic phenomena are almost invariably the result of a plurality of causes. But so far as the advance in prices is common to all countries, it cannot be ascribed to tariffs or trusts, to short crops or short hours of labor, to speculation or taxation, or anything else which operates only locally. We must look deeper for a force or forces that are universal, world-wide. And such a force is to be found in the output of gold since 1896.

I have copied from the last report of the director of the United States mint (1908)—which gives the world's production of gold since the discovery of America—the following table which is sufficient for our discussion.

WORLD'S ANNUAL PRODUCTION OF GOLD.

1721-1810	13,287,000
1811-1830	8,527,000
1831-1840	13,484,000
1841-1850	36,393,000
1851-1860	133,000,000
1861-1870	126,000,000
1871-1880	115,000,00
1881-1885	99,000,000
1886-1890	112,000,000
1891-1895	163,000,000
1896-1900	257,000,000
1901	260,000,000
1902	296,000,000
1903	327,000,000
1904	347,000,000
1905	380,000,000
1906	402,000,000
1907	412,000,000
1908	441,000,000
1909 (estimated)	457,000,000

You will notice that we are considering the world's output and not the output of this country alone. We do this because of the freedom with which gold flows where it may be needed for the world's work. The British Isles, the world's greatest market, produced less than $30,000 in 1908, and yet there was no scarcity of gold in England. France produced less than a million ($835,000) in the same year, but she imported 196 million. Africa produced 166 million in 1908 but exported 160 million. Gold is not perceptibly more valuable in the country that produces none than in the country that produces hundreds of millions annually. A large output in the United States would not make gold more plentiful here than elsewhere. So we must consider the world's output if we are to reach any satisfactory conclusion as to the effect of its increased production on prices.

Again, we consider the world's output rather than that part of it which is coined, made into money. The value of gold, like any commodity, depends on its marginal utility and is governed by the demand made upon it for its use in the arts as well as coin. Of the world's product in 1908, 327 million was coined and 113 million used in the arts.

Now, it does not follow that, because of the large and increasing production of gold in the last fourteen years, prices must of necessity have advanced. If the world's commodities increase in amount faster than the means of exchanging them—other things remaining the same—prices will fall.

It could easily be shown, if time permitted, that this has not taken place in the United States since 1896; indeed in the case of some foodstuffs there has been an actual decrease in amount. And a decrease in the amount of any commodity, attended by a large increase of the force available for money-work, must result in a great increase in the price of that commodity.

Now, greatly as the world's output of gold has increased since 1896, as indicated by the report of the director of the United States mint, the force available, through bank credits, for the exchange of commodities has increased vastly more. That the gold output has increased the per capita circulation in the United States from less than $23.00 in 1896 to about $35.00 at the present time, is in itself significant, but when we consider how greatly this is augmented, by means of bank credits, it becomes much more significant. Not everyone is familiar with the fact that for every dollar in cash deposited in a bank the bank may safely lend at least five dollars. This is because banks do not lend money so much as credit. Probably not more than 10% of a bank's loans is made in money. What borrowers want is not money but a right to draw money. So instead of taking the money from the bank they deposit it to their credit. Banks, in this way, as is sometimes said, "manufacture credit." They enable the community to use money to the best advantage; they make a little money do a great deal of money-work. While, therefore, the per capita circulation in this country has not increased over 50% since 1896 the money-force available for effecting exchanges has increased by five times that amount. The commodities to be exchanged have not increased so much. To use a phrase of Francis Walker the money-work to be done has not increased as fast as the money-thing, and consequently prices have lifted.

But there is no reason to suppose that this advance in prices will continue indefinitely. Gold was excessively high in value in 1896, and gave large returns to its producers. Now, it is a familiar fact that labor and capital are constantly attracted from less profitable to more profitable industries. It was more profitable to produce gold in '96 than to produce wheat or raise cattle, and so capital and labor turned to the production of gold. Gold production went on at a prodigious rate while that of wheat and other foodstuffs did not. Moreover, because of the large returns, from the mining and refining of gold, the inventive genius of our engineers and chemists was directed towards finding better and cheaper methods of producing it, and the result is our modern cyanide process.

But mining is an industry especially responsive to the law of diminishing returns. Ore must be sought on lower and lower levels, thus increasing the cost of producing it. This, together with the present diminished value of gold, will induce labor and capital to forsake the search for gold and enter other and more profitable fields of production. The result will be a diminished output of gold and a fall in the price of other commodities (which is the same as a rise in the value of gold).

All this, however, takes time, and meanwhile we must submit to high prices, unless we can find some means of averting them. It would, of course, make little difference, so far as the cost of living is concerned, whether prices are high or low, whether they go up or go down, if only wages, salaries, interest and the like, moved in the same direction and with the same degree. Real wages, salaries and other incomes would then remain unchanged.

But this never occurs. Wages and salaries are slow to respond to the changing value of money. The April number of the Atlantic

Monthly, just out, asserts that salaries actually fell 6.96% in Massachusetts, from 1895 to 1905, which means a very large fall in real salaries.

As a means of preventing this rise and fall in real incomes—and so in the cost of living—the adoption of the multiple standard has recently been advocated by some writers of note. This would furnish an equitable solution, if it could be made to work in practice as it is conceived in theory, which is highly improbable. The multiple standard is not in use anywhere at the present time, so far as I know, nor has it ever been on an extensive scale. It is too much, therefore, to predicate its practicability. Moreover, the world is committed, for the present, to the gold standard, and, while it is by no means a prefect standard for deferred payments, we probably cannot do better than to continue it. At any rate we could not change it if we would. It only remains for us, then, to adjust ourselves, as best we may, to it.

But how? So far as I know, no suggestion has yet been offered, except to extend the principle of protection to gold. But legislation with regard to gold would probably not be effective. Most likely it would do harm rather than good. A partial remedy might be found in better and freer banking laws, such as exist in some foreign countries.

And then, too, if wages, salaries, interest and the like could be made to respond more quickly to the changing value of the standard, gold, a long step would be made toward the solution of either an increased or diminished cost of living. It has seemed to me this might be accomplished by the appointment of a body of economic experts of recognized ability and character, who should determine by the science of index numbers, whether prices have lowered or lifted and to what extent. These determinations might be made, perhaps twice a year, and published in the daily press. If prices had greatly increased, as has been the case recently, these reports would become subjects of discussion in press and magazine; public opinion would be created in favor of a demand for higher wages, salaries and other fixed incomes. This should be especially effective in the adjustment of wages, and it is, after all, the laboring people for whom we are most vitally concerned in the problem of the high cost of living.

Alma College, Mich., April 1910.

ORGANIZED LABOR AND THE RECENT ADVANCE IN PRICES.

LEWIS H. HANEY.

This paper is written in view of two facts: prices have risen; wages have done likewise. According to all methods of statistical judgment average prices are between 30 and 40% higher than at the low level of 1897; just now no one can estimate the rise in average wages during the past two years, though it has probably been less than that of prices, just as it was somewhat greater in 1897 and 1903.

Now, various phenomena are pointed to and mentioned as causes for this advance in prices. Some say gold supply, some vanished free land; some growl labor unions, others hiss "Trusts!" My problem is to take the labor factor and inquire how it has functioned in the general rise. What is the fact as to wages? What is the relation between wages and prices? What part has "organized labor" played in the determination of this relation?

I. GENERAL PRICES AND WAGES.

We at once reflect that a general rise in exchange values is inconceivable to the intelligent mind, and are forced to make first the distinction between price and value, and then that between general values and prices and particular values and prices.

General *prices* may rise, for here the question is not one of a ratio of exchange between commodities, but between commodities and a medium through whose agency the commodities are exchanged: the general *rate* of exchange may be higher or lower according to relative conditions of supply and demand as regards the medium.

General prices, then, may rise through changes in demand or supply of money, money being defined as all media of exchange: if the quantity of money or its efficiency of circulation increases, or if the number of exchanges to be effected decreases, general prices will rise. Obviously labor may function here as a factor in producing either media of exchange, or things to be exchanged. But the facts are patent: on the supply side money has increased tremendously in quantity; bales, bushels, tons and ton miles on the demand side have also waxed, but apparently the supply side has grown faster and each year the dollar is worth less on the average. Without going into a wearisome statistical statement it may simply be stated that there appears to be no evidence that the production of commodities as distinguished from money has lagged. I leave it for others to decide if the whole change be due to the increased supply of precious metals and other money media.

So far as general prices for any considerable time are concerned it does not appear that wages have effected or can effect a rise in price. It would be out of place in this paper to go into the theory of the fact, and explain why there is no logical connection between general wages and general prices. As to the facts, statistics show no great parallelism

in advance, and wages follow rather than precede prices in the upward movement. If curves indicating the course of wages and that of prices are plotted and compared it at once appears that a drop in prices nearly always precedes one in wages and that the drop is generally at a lower rate in the case of wages.

The facts as to the movements of general wages (so called) are briefly as follows. The index number of full-time weekly earnings used by the U. S. Bureau of Labor—based on a weighted average by industries with the average for 1890-99 as 100—was 99.9 in 1898, 104 in 1900, 114 in 1905, and 122.4 in 1907,—a rise of 22.4%. This seems quite representative as tested by the statistics of certain states. New York, for example, publishes an index number for 46 industries,—unweighted, and with the average for 1899-01 as 100,—which starts at 92 in 1898 and ends with 122 in 1907,—an advance over the base of 22%. Taking Ohio's figures and roughly constructing an estimated series with the average yearly earnings for 1899-01 as a basis, we get an advance of 19%. New Jersey's statistics of yearly earnings makes the index number for 1907 equal 116,—the average for 1899-01 being 100. As compared with 1898 these figures show a rise in average earnings of from 18% to 30% for 1907. The figure for the United States, 22.5, lying approximately half way between seems conservative.

The movement of relative wages during the decade 1898-1907 is shown in the following table.

Year.	U. S. (1890–99 =100).	N. Y. (1899–01 =100).	N. J. (1899–01 =100).	Ohio. (1899–01 =100).
1898	99.9	92	98.0	94.9
1899	101.2	100	99.1	97.4
1900	104.1	97	99.9	98.2
1901	105.9	103	100.9	104.4
1902	109.2	105	105.6	109.9
1903	112.3	109	106.5	113.2
1904	112.2	108	106.3	112.1
1905	114.0	115	110.1	114.9
1906	118.5	122	112.0	118.7
1907	122.4	122	116.9	118.9

II. THE TRANSITION FROM PARTICULAR TO GENERAL.

But new general price levels do not come in one "fell swoop" and, as Hume long ago pointed out and Cairnes emphasized, changes in general prices come through a series of changes in particular levels.

Nor is the truth of this statement overshadowed by the course of the various general index numbers referred to. In all cases some prices have remained stationary and others have fallen while the average is advancing.

The key to the present price and wage situation seems to me to lie in the following explanation. First there comes an increase in the supply of money media (as already indicated by Prof. Mitchell). Then as this supply increases, the holders of it begin to find its exchange power decreased here and there according to the demand for particular commodities, or, put in another way, its marginal utility to them, decreased. First, such farm products and food articles as cotton, corn, butter,

and eggs feel the effects of the rising tide of money. The demand for them being intense and inelastic, the money holders are impelled to part with more units of their medium to secure the desired amount of such goods. In a word, wherever supply is limited relative to demand prices will rise, and *where the limitation is greatest—where the means of satisfying an inelastic want are scarcest—there the price will rise first.* Finally, if we assume that no changes in the character of wants or the means of satisfying them takes place, the rise will spread from one industry to another and affect all in the same proportion.

It is thus easily explainable that food stuffs, for which man's wants are least elastic, and the demand for which in the shape of a swelling population has just begun to exhaust the old sources for new supplies,—that food stuffs should show the earliest and highest rise. Housing, fuel, and light are the objects of a relatively inelastic demand and have risen in price to an extent only second to food stuffs. Clothes have a more elastic demand: here relative prices are not now so high.

But what of wages? If we assume competition it is evident that it will spring up with and among those employers who receive the advanced prices and will insure an advance to labor, at least until some growth in the labor supply brings a counter competition and reduction. This last qualification will probably be unnecessary, however, for the rise in prices becoming more general, the cost of living will be increased so that more money wages are requisite to insure the same real wage as was received prior to the rise. The price of cotton goods, bread, cattle, and leather goes up, and so on until the whole budget of the laborer and everyone else is affected.

But if there is an element of monopoly on the part of capital in the favored industry the rise may not be transmitted through it to the industrial system, but be retained as a surplus profit. Nor would the laborer's wages in that industry be advanced unless he too were a member of a (labor) monopoly and forced a division, or until rises outside his industry made an advance necessary to the maintenance of his standard.

In a word, the advance in wages follows that in prices. The chief concessions to those who would attack labor organizations in this connection would be made in pointing out that a monopolistic union in an industry whose products were the object of an inelastic demand might make that demand more intense by limiting supply and so determine the point in the field of industry at which prices would first rise,—a case of *particular* prices.

The next question would be one of fact. Is there any evidence of such action? Naturally we transfer our attention to what is the real problem of the hour the question of the relation between particular prices and particular wage groups.

III. PARTICULAR PRICES.

Turning to particular prices the problem is less simple. Here anything which limits the supply of a commodity relative to demand may cause a rise in its price, whether this be monopoly, or increased cost of production, or absolutely limited supply. Here is the field for increased labor costs or expenses to express themselves. Do employes

in building trades monopolize their crafts? Then, the number demanded remaining the same, the price of houses will rise. Does it cost more labor to produce a bushel of wheat? Then that bushel will bring more on the market. Or if the demand for sirloin steak increases very much the price of steak may rise even though the cost may decrease somewhat. Probably, when the question is put, what is the cause of the recent high prices, no answer is so frequently in the mouth of the nonscientific man as "organized labor."

In approaching this phase of the problem it will be well first to analyze the theoretical possibilities and then to bring such statistics as are available to bear.

1. *Relative Productivity* (a) *Productivity:*

One way of putting the case is this: If wages are raised relatively to productivity the price must be raised or the capitalist enterpriser will lose. I say "raised relatively to productively"—it will be noticed that this may take place in one or both of two ways: either the *rate* of wages may be raised, productivity remaining the same; or productivity may be decreased, the rate remaining unchanged. Let us consider the latter event first.

Now labor's productivity, equal opportunity being assumed, is reducable to three factors,—energy, time and skill. If a workman puts forth great effort for a maximum length of time[1] on a high plane of skill he is very productive. If anyone of the three factors is lowered or diminished, his productivity decreases.

Of course a similar result would come from poorer opportunities in natural environment or a lower margin. This would not be attributable to labor, however, and is mentioned only that it may be borne in mind as an alternative or modifying factor.

Does organized labor, then, decrease productivity relatively to wage? If so, through which of the preceding factors does it operate?

As to the energy factor, I am unable to get any data which can be taken as proof. It is a matter of common knowledge that the "go-easy" or "make-work" or work-fund idea has been widespread and still exists. We know that laborers work harder in years of depression than in boom periods, etc. But these ideas and moral characteristics are not confined to union laborers, and are becoming more and more disclaimed by union leaders. It seems that all that can be said is (1) that if the go-easy policy obtains among *all* laborers equally prices will not be affected by it; (2) that if in particular trades laborers have adopted this policy within recent years, recent price advances in such trades might be due to this policy; (3) that we have small reason, however, to lay the exercise of this policy at the door of organized labor, and none for attributing to it the recent rise in prices, for there is no evidence of any recent change in this regard.

More evidence can be obtained as to the second or time factor. There has been a steady decrease in hours throughout the decade, the index number for 1898 beging 99.7[2] while that for 1907 was 95.0,—a decrease of 4.7%. The demand for and prevalence of the eight-hour day is greater than ever before. To the extent that this means decreased

[1]From a long-time point of view the working day would not be so long as to shorten the total working period of the laborer's life unduly.

[2]Average for 1890-99=100.

productivity[1] generally, it means less product per laborer, and might mean a decrease in the "national dividend" or "social income." This would be a misfortune, but it would necessitate no change in general price levels. Only when confined to particular industries or trades, and not generalized, could exchange values and prices be affected. What, then, are the facts?

The average index number of hours per week for 15 relatively weakly organized industries was 96.2 in 1907. In the same year the average for 8 strongly organized industries was 93,—a difference of 3% in favor of the stronger unions. When it is observed that such strongly unionized workers as cigar makers, and blacksmiths and horse shoers have index numbers of 99.5 and 94.1 respectively; while common laborers in foundry and machine shops, lumber, and paper and wood pulp have 95.3, 95.2, and 94.5, respectively, the difficulty of drawing conclusions is apparent.[2]

I conclude that on the whole organized labor has forced greater reductions in hours than have occurred in the case of unorganized laborers and that *other things being equal* this would tend to raise the particular prices of the good they produce. Whether other things have been equal and prices of organized labor's products have risen at the expense of other products will appear in a moment.

As regards the third factor, skill, I must be content with observing that to the extent trade unions force employers to use skilled men where unskilled men—handymen, helpers, etc.—could do the work, they may virtually decrease productivity relatively to wage, or, more simply, increase or prevent a decrease in cost. To what extent this is done there is no means of learning.[3] (Of course, if skill be considered alone or absolutely, and not in relation to cost, it will generally be admitted that *on the average* the most skilled men of the craft will belong to the union and unions rather foster than decrease skill.)

(b). *Wage Rates.*

As to the movement of the other factor in "relative productivity," i. e., of rates of wages, some inferences may be drawn from the statistics

[1]Shorter hours may increase energy and skill.

[2]Table showing relative hours per week for weakly organized and strongly organized industries:

Weak.		Strong.	
Agricultural Implements	96.3	Bread	91.6
Boots and Shoes	96.0	Blacksmith and horseshoeing	94.1
Carpets	98.6	Building	90.6
Cars	95.9	Harness	95.9
Cotton Goods	96.8	Brewery	87.0
Electrical Apparatus and Supplies	93.3	Stone and Marble	93.6
Foundry and Machine Shop	94.6	Printing	92.4
Gas	96.1	Cigars	99.5
Glass	98.6		93.0
Hosiery and Knit Goods	97.7		
Iron and Steel { Bessemer	90.5		
Iron and Steel { Blast	100.6		
Leather	99.9		
Paper	89.9		
Silk	97.6		
Woolen Goods	98.0		
	96.2		

[3]Nice questions of social justice would be involved in answering the question, might this not be done justly, as a short-time policy, anyhow?

of wages and hours of labor from 1890-1907.[1] From the table on page 10, I conclude that of those rises in wages which are above the average rise there are more in case of weakly organized trades than in case of a strongly organized one. Furthermore, the average of relative wages in 1907, though it seems somewhat lower for weakly organized industries than for strong, shows no such difference as to indicate any effect of unions on particular prices. The average index number for 15 weakly organized trades was 125; for 8 relatively strong trades it was 130.

Weak.		Strong.	
Agricultural Implements	130.9	Bread	128.9
Boots and Shoes	124.3	Blacksmithing and Horse Shoeing	126.4
Carpets	117.1	Building	144.6
Cars	124.4	Harness	123.5
Cotton Goods	157.5	Brewery	132.9
Electrical Apparatus and Supplies	122.6	Stone and Marble	125.7
Foundry and Machine Shop	121.4	Printing	126.8
Gas	129.4	Cigars	132.4
Glass	123.5		
Hosiery and Knit Goods	133.4		130.1
Iron and steel { Bessemer	119.8		
Iron and steel { Blast	132.6		
Leather	111.8		
Silk Goods	116.9		
Slaughter and Meat Packing	116.0		
Woolen	131.9		
	125.8		

Can we not infer, then, that *if other things were equal* the tendency of labor organization would be through effecting relative productivity to cause higher prices in the organized part of the industrial field than in the unorganized, and also in the strongly organized as compared with the weakly organized part; and (2) that the scanty statistics as to hours and wage rates show that on the average this is the case, though (3) no such marked differences as might be supposed appear.

Inasmuch as positive conclusions from this examination of the possibilities and actualities of the more immediate means of affecting prices are so meagre we must seek results elsewhere. We have concluded that the only way in which laborers can effect a rise in prices is to decrease relative productivity in a particular industry or group of industries through one or more of the factors just briefly discussed. But the ability to make such a decrease depends upon the strength of organization—of the union: just as, in so far as prices are concerned, a union can work only through a change in relative productivity, so the capacity to affect relative productivity and prices depends upon the strength of the union.

To be sure we can not measure changes in relative productivity. Merely a few deductions have been suggested. Therefore, when a

[1]Bulletin, Bureau of Labor, No. 77.

presence or absence of such price changes as altered relative productivity would effect is found corresponding with the strength of labor organization, I can not be so sure as to a causal connection. But knowing something of the possibility and tendency of labor organization in this regard some deductions may be drawn when strength of organization is found coupled with relatively low prices, and *vice versa*. In a word, conclusions negative so far as causes are concerned may be drawn, and for the problem concerning the relation of organized labor to prices negative conclusions are all that is necessary.

2. *Strength of Organization and Prices.*

I take it that to show by good statistics that prices have risen as fast and as much in weakly organized or unorganized industries as in those which have strong unions, will disprove the common contention. Take, then, the most general comparison available,—that between raw materials and manufactured goods. It matters not that the line can not be drawn exactly. It is reasonably certain that trade unions have their great strength in the more skilled manufacturing industries; and, that, with the exception of a considerable part of the bituminous coal producing industry, the laborers engaged in producing raw materials are unorganized or but weakly organized. Yet the latest statistics show advances in the index number of wholesale prices to 125.5 in the case of raw materials and to but 122.2 for manufacturers, the average for 1890-99 being 100.[1]

RELATIVE PRICES IN UNORGANIZED INDUSTRIES.

	1908.	1907.
Cotton	134.8	153.0
Grain	163.0	148.3
Livestock	122.3	129.7
Average Farm Products	133.1	137.1
Fish	124.9	128.3
Milk	131.4	129.0
Eggs	142.0	141.2
Average Food Products	120.6	117.8
Jute: Raw	140.4	184.4
Average Misc.	119.9	127.1

More particularly. Farm products head the list of certain great groups at 133.1, the average for all products being 122.8. Next come lumber and building material at 133. Foods are estimated at 120.6. On the other hand clothes and clothing have risen to 116.9; house furnishings to 114; metals and implements to 125.4; and fuel and light to 130.8,—the last containing many non-union and weakly organized occupations.[2]

But let us make the comparison still more particular, and more direct. Take a group of industries in which unionism is strong and compare those with other industries in which it is weak. Here the difficulty which at once confronts one is that we do not know with any accuracy

[1]Bull. Bur. Labor, No. 81, p. 209. Wholesale prices, 1890-1908.

[2]The difficulty here lies in the fact that each of these groups—except the first—contains some strongly organized trades. Conclusions are difficult except as we roughly estimate the relative extent of such organization.

what the weak and what the strong ones are. And in other cases some knowledge on this point may avail us nothing in that it would be impossible to estimate what part of the product whose price has risen is assignable to the known union. It goes without saying that mere absolute numbers, notoriety, etc., are scant evidence of strength. It is necessary to turn aside for a moment to pick our strong and weak unions.

In the report of the Commissioner of Labor for 1906 there are sundry tables concerning the number, extent, and success of strikes by States and by industries for the years 1881 to 1905. On page 33, for example, a table shows the percentages of strikes ordered by labor organizations by industries. I find that in a considerable number of industries a large percentage of strikes is not ordered by such organizations.[1] This proves nothing for my purposes, it is true. It does not indicate much as to the strength of any particular *trade* organization in some cases, and is not conclusive in any case. It merely affords some presumption as to the average control of trade unions in a whole industry for a series of 25 years,—control over the declaration of strikes.

The result is virtually identical if the percentage of establishments affected by strikes declared by organized labor be taken rather than the number of strikes.

But other tests remain. What proportion of the employes went out on strike when ordered by labor organizations? i. e., how inclusive were the unions? I find that the list of low percentages is almost identical with the list judged to be weak on the preceding basis. Perhaps 8 of the industries indicated as weakly organized by the preceding test show greater strength[2]; while 4 industries would be added to the weak list.[3]

I turn to another table which shows the results of the strikes ordered by labor organizations during the same 25 years. On the whole there is a very striking similarity in the indications as to strength and weakness. The result of applying the new test is that a question mark must be placed after 5 out of the list of 32 suspected of weakness on the preceding bases;[4] while one additional industry shows weak labor organization in a large percentage of strike failures (strt. ry.)

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[1]Agriculture.
Brass and brass goods.
Brick and tile.
Canning and preserving.
Car building.
Carpets.
Coal and coke.
Cotton goods.
Cutlery, etc.
Freight handling and teaming.
Gas.
Glass.
Hardware.
Hosiery and knit goods.
Iron and steel.
Leather.
Lime and cement.
Lumber and timber products.
Mining, ore.
Paper and paper goods.
Pottery.
Railroad, canal and road building.
Railroad transportation.
Rubber goods.
Silk goods.
Smelting and refining.
Tobacco, chewing and smoking.
Woolen goods.
(One or two others.)

[2]Agriculture (69%).
Brick and tile (72%).
Coal and coke (76%).
Freight handling and teaming (63%).
Lumber and timber (55%).
Mining, ore (57%).
Silk goods (51%).
Smelting and refining (53%)—the last two are obviously not strong.

[3]Boots and shoes.
Foundry and machine shop.
Slaughtering and meat packing.
Stoves and furnaces.

[4]Hosiery and knit goods.
Lumber and timber products.
Paper goods.
Pottery.
Tobacco, chewing and smoking.
However, 91% of strikes in hosiery, etc., were "unorganized" and 61% of *all* strikes failed. Taking all strikes, 49% failed in lumber, which is above the average, and paper goods and pottery are only average in success on the same basis.

Finally, there is a table of strikes settled by joint agreement, that is, between officials representing organizations on both sides. Surely those industries in which strikes are largely settled in this way are strongly organized, though perhaps not vice versa. Not one of the industries showing any considerable percentage of strikes so settled falls in our list of weak unions, unless it be decided that freight handling and teaming and coal and coke are weak.[1]

It may be added that an examination of the statistics published by the Connecticut bureau showing movement of number of employes, wages, and hours by industries may be made the basis for conclusions which support the preceding.

The net result of the inquiry is the conclusion that the following industries taken as a whole show that labor organization is least effective in them.

Rubber goods.
Canning and preserving.
Mining, ore.
Cotton goods.
Hosiery and knit goods.
Hardware.
Iron and steel.
Car building.
Carpets.
Woolen goods.
Silk goods.
Leather.

Those industries in which unions seem most effective are:

Blacksmithing and horseshoeing.
Men's clothing.
Bakery.
Brewing.
Building trades.
Gloves and mittens.
Stone quarrying and cutting.
Tin and sheet metal goods.

Coal and coke shows strong in extent and inclusiveness of organization, but rather weak in failures of organized strikes (47%). It seems clear that labor organization is strong in a considerable part of the bituminous coal area, but weak elsewhere.

Returning to the comparison, to make which we turned aside to inquire into the relative strength of labor organizations in various industries, the conclusion must be drawn that no appreciable effect of organized labor on the rise of particular prices during the last decade is apparent. Comparisons are available for the following weakly organized industries:

[1]The most notable, taking number and per cent. into consideration:
Blacksmithing and horseshoeing.
Brewing.
Building trades.
Coal and coke.
Stone quarrying and cutting.
Others are: Men's clothing, freight handling, planing mill products, and cigars and cigarettes.

	1908.	1907.
Rope, twine and bagging	121.0	138.0
Cotton goods	115.2	138.0
Carpets	118.9	123.2
Iron and steel	113.9	135.3
Woolen goods	122.7	128.0
Tools	113.6	115.7
Boots and shoes	121.3	125.9
Average	118.0	128.4

The average relative prices for the group of 7 is 118 in 1908, and 128.4 in 1907.

I experienced more difficulty in finding strongly organized industries for which prices were available. Among the strongest only two such were found (bread and coal) neither of which affords satisfactory conclusions. But adding five of those which were much stronger than the ones included above, I find that the average relative price for the years 1908 and 1907, respectively, is 119.0 and 119.9.

	1908.	1907.
Bread	113.6	111.4
Coal	132.7	134.2
Lime and Cement	107.4	104.3
Tin and Sheet Metal	110.5	115.7
Tobacco: Chewing and Smoking	118.3	118.3
Paper	86.7	87.4
Lumber and Timber	164.0	168.6
Average	119.0	119.9

Thus in 1908 the index number of prices in 7 weakly organized industries was one point lower than in 7 relatively strongly organized ones; while in 1907 it was actually 8.5 points higher. The year 1908 was one of generally lower wholesale prices than in 1907, and it is not without significance to note that the more strongly organized industries showed the smaller decrease.

Massachusetts statistics show that for the year ending September 30, 1907, 98% of advances in wages occurred without strike. And of these at least 67% were not the result of any immediate union activity. The amount of the advance, however, was somewhat less than in the 33% in which unions figured.[1]

[1]First Annual Report on Changes in Rates of Wages.

IV. COST OF LIVING.

If the conclusion is that wages have risen rather as a result of high prices than as a cause, the next question is, what has been the effect upon the wage earner? This brings me to the subject of cost of living and purchasing power of wages. At least three investigations of this general phase of the matter are worth mentioning: that by the United States Bureau of Labor on retail prices of food, 1890-1907;[1] the more recent one made by the New York Bureau of Labor;[2] and the index numbers of retail prices published currently by the New Jersey Bureau of Labor.

The results obtained by the national bureau of labor for 1907 show a rise in full-time weekly earnings to 122.4 and a rise in the weighted average of retail prices of food to 120.6. Taking the average for 1890-99 as 100 this means a relative purchasing power of 101.5. That is, average weekly earnings will buy 1.5% more food in 1907 than on the average for the decade 1890-1899; about the same as in 1898 and 1899; 1.5% less than in 1900, and 9% less than 1906. This comparison is inadequate, of course, in that food alone is considered. When we remember that the wholesale prices published by the bureau indicate an even greater rise in cotton, furniture, metals and implements, lumber and building materials, and such miscellaneous commodities as rubber, rope, and malt, the situation is scarcely one for optimism.

Nor is this all. It is obvious that no allowance is made for progress,—for an advance in standards of living. This procedure runs counter to the spirit of American economic theory and would be accepted by few. To be sure it is impossible to make any exact allowance for this element, but when purchasing power of average earnings remains as low or lower at the end of a decade as at the beginning, there is ground for some degree of pessimism.

The figures[3] obtained by the New York bureau appear more satisfactory, yet the statistician points to the omission of the standard of living element and is not at all optimistic in his tone.

Briefly the results are these, 1907 being compared with 1897:

Retail Prices (1899—01=100)		*Income.*	
Food	123	Wages rate (union)	122.9
Rent	124	Average Quarterly	
Fuel	115	Earnings	131.2
Light	84		
Clothing	120		
Furniture and Utensils	119		
Average	122		

The New Jersey Bureau compiles for various representative localities statistics of the retail prices of table supplies, all those articles of food most commonly used by families of average means being included. Taking the average of the years 1899-1901 as 100 and reducing the costs

[1]No. 77.
[2]25th Report, Bureau of Labor Statistics, Chapter V.
[3]Retail prices obtained from representative firms and averaged, being weighted according to the method used by the United States Bureau.

of such a bill of goods in the various years of the decade to index numbers, I find the result shows a relative price of 104.5 in 1901, 109.4 in 1904, and 123.1 in 1907. These, however, are the high points. Such truth as there is in the New Jersey figures is best presented by taking three-year averages. The average for the index numbers for the three years 1899-01 equals 99.9; for 1902-04 equals 102.5; for 1905-08 equals 107.3.

It will be remembered that the New Jersey average wage produced an index number of 116.9 in 1907, which shows rather darkly against the food index of 123. The comparison is difficult, however, in that the prices show such great fluctuations, and smoothing the curve by taking two or three-year averages brings much brighter results.

It is hardly necessary to add that, according to the law formulated in the above brief discussion of prices, the advance has come in just those commodities which Engel and other investigators have shown to form the great percentage of the laborers' budgets and for which there is a relatively inelastic demand. The result is that the laborer[1] is hit in the hardest way, hit "right where he lives," as we say, and is hit harder than those of any other class.

Summary: After indicating that general prices have not been affected by labor organizations I took up the question of particular wages and prices, in the transition noting that changes in price and wage levels become general through changes in particular prices and wages beginning where scarcity meets an inelastic demand. As to particular prices the theoretical possibilities of labor organizations were pointed out and the conclusion that there has been no great nor widespread effect upon them. Organized labor has reduced hours, but it is not clear to what extent this means decreased productivity nor has the reduction been confined to organized labor. There seems to be no great difference in price movements as between strongly organized and weakly organized industries, while the greatest advances have come in unorganized industries. In fact it is not clear that wages have risen adequately. Making no allowance for increase in standard of living average relative wages had risen to a greater extent than average relative prices in 1907; but the price and wage lines were converging and I do not carry away an optimistic feeling from my study. The present demands for wage advances being made all around us and largely granted by employers are indicative of the situation and show the hope and the benefit of labor organization.

April 1910.

[1]Including lower-salaried workers.

THE INFLUENCE OF THE TARIFF AND MONOPOLY UPON THE INCREASING COST OF LIVING.

FRANK TRACY CARLTON.

It is only stating a truism to remark that the causes of social and economic phenomena are complex and often hidden rather than simple and readily apparent. Many potent forces have been acting during the period 1896 to 1910 to raise the price level, and, therefore, to increase the cost of living,—among such agencies are the increasing supply of gold, the efforts of organized labor, the disappearance of free land, diminishing fertility of the soil, the depletion of certain natural resources, wasteful methods of producing and of consuming, and so on thru a list which is not short. These and other influences are affecting the price level. Altho consideration, in this paper, must be given almost solely to the influence of the tariff and of monopoly upon the price level; it is by no means implied that there are no other agencies of importance.

While indirectly the protective tariff may have played an important role in raising the price level during the last decade and a half; directly it must be assigned to a minor part. Two reasons may be presented in order to substantiate the latter part of the above statement which is diametrically opposed to arguments frequently presented. (1) Attention is directed to the fact that no important change in the tariff has taken place since 1890; or, if this be questioned, certainly not since 1897. In the absence of monopoly, or in other words in the presence of competition, prices soon adjust themselves to new tariffs. Important changes in prices due to the imposition of a tariff follow closely the enforcement of such enactments. The tariff could not directly cause a gradual or a rapid increase in the cost of living over a period of twelve or thirteen years. The imposition of a new tariff might cause a sudden upward price movement; but a uniform price level would soon be attained and maintained unless other and disturbing influences intervened. The tariff may cause high prices; but it, acting alone, will not cause prices to gradually rise thruout a period of years. The rapid upward trend of prices during the last few months may possibly be due to the passage of the Payne-Aldrich bill; but if the upward trend continues it must be attributed to the action of other forces or to the indirect effect of the new tariff. Before this group of students of economics, it is surely unnecessary to enter into a detailed discussion of this point.

(2) In these days of full-grown industry in the United States a protective tariff upon articles which Americans are manufacturing on a large scale will have little or no effect, except temporarily, upon prices,—providing competition actually exists as a potent force on this side of the Atlantic. Of course this statement may not hold true in the case of all articles of home manufacture. Other countries may have certain special advantages in the manufacture of certain products. It seems reasonable, however, to assert that without monopoly or consider-

able interference with the freedom of competition, an old tariff placed upon staple products of American agriculture or American manufacture will have little effect upon prices. Many argue that wages are higher in this country than abroad and therefore the prices of certain goods will necessarily be higher in this country than abroad; but in view of the multiplication and cheapening of the means of communication and of transportation, in view of the large numbers of immigrants which are annually added to our labor supply, and in view of the low average annual wage paid in this country, it is not unfair to declare that it is not proven that wages in comparison with output are higher in the United States than in England or Germany.

In so far as the tariff is a factor in raising the prices of products which are regularly produced within the country in quantities sufficient to satisfy the home demand, its action is the result of the development of monopoly, partial or complete. The existence of the tariff wall may have hastened such development as the tariff wall wards off the danger of outside competition.

It is granted that a tariff on goods not produced within the country or produced only in small quantities will directly affect prices; but the effect will be noticeable soon after the imposition of the tariff. The effect, as before stated, of such a tariff will not be such as to cause a constant upward trend of prices. But barring these cases which may arise under a tariff for revenue only as well as under a tariff which is primarily protective, the problem before us may be reduced to a consideration of the indirect effect of the tariff.

On the other hand, a protective tariff accompanied by monopoly or by interference with freedom of competition, may be indirectly a very potent force in affecting the price level of the protected articles, and, by working back into the expenses of other than protected businesses, the price level of a multitude of articles and services. The tariff is, therefore, chiefly important in the discussion of the increasing cost of living in so far as it has fostered monopoly or has hastened the organization of combinations which tend to destroy competition. Our problem may now be restated by omitting the word tariff from the title. What is the relation between the development of monopoly and the increasing cost of living?

The normal effect—the effect in the absence of monopoly—of the development of large-scale, systematized industry is to reduce the expenses of production, and, therefore, to reduce the level of prices for all articles made under large-scale industrial methods. The period of rising prices, 1896 to the present moment, has also been an era of consolidation and integration of industry, accompanied by the speeding up of workers and machines and by an increase in the product turned out per wage earner. Looking at the matter solely from the side of industrial management, the period, 1896 to 1910, should have been one of declining prices. On the contrary, this era marked by improved industrial efficiency, has been one rapidly rising prices.

The swelling gold supply is one potent force which has caused the price level to rise; but this agency ought to act fairly uniformly thruout the Western World. An official English Report estimates that food prices in that country increased nearly eight per cent in the period,

1896 to 1906. The U. S. Bureau of Labor estimates that the price of food on this side of the Atlantic was raised over twenty per cent during the same ten year period. The London Economist has tabulated an index number which shows an increase of 27 per cent, June, 1897 to January, 1910. Bradstreet's index number shows an increase of 61.9 per cent from July 1, 1896 to January 1, 1910. Professor Norton of Yale estimates that the ratio of the recent price advance in the United States to that in England is as 3 to 2. A German statistician has estimated that the appreciation in the price of the articles most necessary to the household of the German wage earner was, during the period, 1895-1908, approximately 27½ per cent.

Both the United States and Germany have witnessed greater progress toward industrial amalgamation and systematization during the last fifteen years than has England. If the price level is being forced up chiefly by an increasing gold supply, and if competition operated freely behind tariff walls; England, not the United States and Germany, should present the most marked advance in prices. Evidently, other agencies have been acting to raise the price level during a period when consolidation, integration and systematization of industry are reducing the expenses of production. Is monopoly one of these agencies? Are increasing land rents, growing monopoly gains, swelling returns from franchises, and the like, absorbing a larger and larger percentage of the national output, and, therefore, acting so as to tend to force the price level upward? Is the burden of rents and of monopoly gains heavy?

The Interstate Commerce Commission, Public Utilities Commissions, the various and sundry attemps to fix fair prices, living wages and reasonable rates, all point unmistakably to the general acceptance of the opinion that competition is not the living, active, vital force or principle which economic theory often so vividly and enthusiastically pictures. In fact, competition has led to combination; and combination bulkwarked behind protective tariffs, franchises, rights of way, land ownership and the economics of large-scale industry has been able to derive a variety of returns many of which were unknown in the realm of untrammeled competition as pictured by the classical and other economists. Monopoly is a potent factor in the economic world; it can no longer be neglected in a study of prices or in a discussion of the cost of living.

Industry in the United States is carrying an enormous burden of fictitious values, or of watered stock. These values are created by capitalizing the large incomes derived because of the control of various market opportunities, and because of the stifling of competition. The rapid trend away from the small business unit and competition toward the large business unit and the control of prices by means of combinations and agreements, furnishes a favorable opportunity to increase the returns upon capital actually sunk in the business and to capitalize those extraordinary returns. The leveling force of competition has lost its potency in most lines of industrial activity; and as yet we are groping in the dark for a substitute.

Not long ago Mr. John Moody estimated that about one-half of the total wealth of the nation is not "created" wealth; in short, one-half of the estimated wealth is fictitious, the capitalization of various forms

of market opportunity. The financial columns of newspapers and magazines tell of "melons" grown in the corporate field, and of frequent stock dividends. But financial melons and dividends on stock dividends are costly. These market opportunity rents are elements of business expense as are wages and interest; and, therefore, financial melons and rising prices are not unrelated phenomena. It is perhaps unnecessary to give examples of the capitalization of market opportunities. The United States Steel Corporation paying dividends on both common and preferred stock is well known. A recent estimate in regard to the Pullman Company shows that the cash and stock dividends paid during the last twelve years aggregates 422 per cent on the capital outstanding in 1898. A conservative magazine has given this example of over-capitalization in the case of a public service corporation which serves several villages in the suburban zone of Greater New York. The aggregate plant, including all machinery, is capitalized at $32,000,000; but it is not actually worth over $2,000,000. The consumers of its products are, however, paying for dividends declared upon the entire amount.

In a neighboring city about ten years ago, a telephone plant was installed. The plant was financed in the usual way. A $1,000 five per cent bond was sold for $850; and, as a bonus, ten shares of the stock of the company,—par value per share, $100—were given to the purchaser. The interest on the bonds has been regularly paid; and the stock—all water—has been paying dividends since the end of the third or fourth year in the life of the company. The dividend rate is six per cent. This company is cited as a typical case.

An official investigation made last year in the State of New York furnishes some tangible evidence as to high prices. The largest company furnishing milk and cream to the people of the city of New York had issued stock to the amount of $20,000,000. Tangible assets to the amount of approximately $5,000,000 were uncovered; the remaining $15,000,000 was declared to be water,—good will, market opportunities, monopoly privileges, etc. This concern was paying six per cent dividends on its preferred stock and ten per cent on its common stock. The price of milk had been raised from eight to nine cents per quart because the company "could make no money" at eight cents. Another and a smaller company paid fifteen per cent dividends in 1908 on its capital,—three-fifths of which was declared to be water. These companies are not public service corporations bulwarked by franchises; they are not gigantic trusts; they sell a highly perishable commodity which is a necessity.

Lawson Purdy estimates that the increase in the value of the naked land in Greater New York in the three years, 1906-1909, was over $500,000,000 or about $100 for every man, woman and child residing in that city. This increase is but the capitalized value of the increase in rentals, present and prospective; and these rentals must be paid for, no matter what theory of the relation of rent to price we may see fit to accept.[1] If the interest rate be five per cent., the increase in the naked land values in New York City in the past three years has caused an increase of $25,000,000 in the total annual expense of living and of doing business in that city. A real estate company is responsible for the statement that during the fifteen years from 1885 to 1900 the ad-

[1]Carlton, "The Relation of Marginal Rents to Price." Quart. J. of Econ., Aug., 1906.

vance in the value of land in New York City was nearly equal to the total advance for 275 years preceding 1885. Again, it may be asserted that increasing land values spell increasing land rents or *vice versa*. And productive industry must pay the growing rent bill of the nation.

A considerable increase in land values is not only noted in the cities and towns, but in the case of farm land as well. For example, a Calhoun county newspaper recently stated that land values in that county had nearly doubled within the past five or six years.

Land rents and monopoly returns, it may be asserted, are two different kinds of income. It must be granted that a technical definition of monopoly will exclude up to the present time the ownership of land from the category of monopoly. But the ownership of a particular piece of land is an exclusive privilege. There can be no duplication of that particular portion of the earth's surface. To own land is to possess a partial monopoly, to be favored by certain unique and special privileges.[1] At any rate, whether land rent is, or is not, a monopoly return, it will, let it be repeated, claim its share of the national dividend,—this is, for our present purpose, the significant fact. To venture to estimate the per capita increase in the total rent bill may not be advisable; but certainly such increase is no negligible quantity, as the one fairly accurate estimate in New York City proves beyond controversy.

Year after year, larger and larger portions of the total national dividend are being absorbed in market opportunity rents of various sorts,—city land rents, returns from franchises and rights of way, forced gains of various sorts due to the elimination of competition, and so on.[2]

An analysis of market opportunity rents will disclose at least two kinds or classes,—differential rents and "forced" or monopoly gains.[3] The former are due to unequal market opportunities. Differential rents do not directly cause high prices or directly increase the cost of living. On the other hand, forced or monopoly gains are direct factors in raising the price level, and are potent factors in increasing the cost of living.

Time permits only a brief reference to certain remedial measures which are concerned with the tariff and monopoly. One obvious suggestion would be to reduce the tariff on articles produced in this country under conditions which approximate monopoly. This might be of, at least, some temporary value; but it would hasten the organization of international combinations which in turn would stifle international competition as has intranational competition been eliminated. Reduction of the tariff, altho desirable, is not of vital importance as a means of preventing the upward trend in the cost of living.

Fundamental remedies must be of two different kinds,—those which are concerned with differential rents and those which are concerned with forced or monopoly gains. The problem is in part that of distribution of wealth. It is not one of lowering the general price level; it is one of lowering specific prices, of eliminating certain monopoly gains, and of diverting other monopoly gains from private pockets to the public treasury. The real problem is to reduce the prices of certain articles and to increase the sum total of services rendered by the community.

Some of the remedies which will prove effective in reducing the cost

[1]Carlton, "The Rent Concept, Narrowed and Broadened." Quart. of Econ., Nov., 1907.
[2]Carlton, "Taxation and Capitalization." The Public, July 10, 1908.
[3]"Monopoly" is here used as the term is used by Professor Ely in "Monopolies and Trusts."

of living are the "increment tax" levied on increasing rents rather than an increasing land values, increasing the tax rate on land rents, taxation of franchises and of rights of way, the regulation of rates, fares and prices, and governmental ownership of public utilities and industries. The taxation of land rents and of monopoly returns will enable the tax rate upon improvements and upon other forms of capital investment to be reduced or eliminated; and the expenses of production will in turn be reduced. Lands and resources which are now withheld from use would be utilized if these forms of taxation were introduced. Forms of rent due to monopoly privileges, forced gains and the like may be reduced, eliminated or absorbed thru proper governmental action.

Obviously, differential rents cannot be legislated out of existence; but differential rents may be utilized to pay the ordinary expenses of government and to extend the activities of government. In short, differential rents may be utilized to increase real wages. "Real wages" in the accepted technical sense means the sum total of the necessities, comforts and luxuries purchased with the money received as wages by the wage earner. But this definition is too narrow. Real wages consists not only in the goods and services purchased with the money wage; but also in the services rendered to the individual by the community. The real wages of individuals may be increased or the cost of living lowered by furnishing at small or no expense to the consumer, the services of the public schools, libraries, parks and of the health department, and such commodities and services as water, gas, electric light, telephone service, transportation, milk and baked goods.

Albion College, Mich., April, 1910.

THE CAUSES OF THE INCREASED COST OF AGRICULTURAL STAPLES AND THE INFLUENCE OF THIS UPON THE RECENT EVOLUTION OF OTHER OBJECTS OF EXPENDITURE.

EDWARD D. JONES.

A review of the history of agricultural prices shows that between 1870 and 1900 there is a period of 30 years during which an important group of agricultural products was low in price. Within this period the lowest prices were experienced in the nineties,[1] and especially in the latter part of them. During the year 1900 a change took place and since that time, with some irregularities, but especially in the years 1901, 1904 and 1907[2] prices have been moving upwards at first gradually, then rapidly. The level of the eighties was passed about 1904. The present prices of corn are above and of wheat very nearly the levels of the last five years of the 60s.

These advancing prices of recent years have for some time been a matter of general comment and if they are a return to normal prices the change is keenly felt because of the long period of low prices by which they have been preceded.

Exhaustion of Free Land.

This thirty year period of low prices was the result of the development of the wonderfully effective American mechanical methods of extensive single-crop farming, and of the opening of a vast area to the market in advance of dense settlement, by extensive railway construction. For a time the fact that this was an exploitive process was its chief merit and was an inevitable result of the conditions. When old lands were abandoned equally fertile ones could easily be annexed to the agricultural area in the west. But of late years warnings have been frequently heard that the process, depending upon free land of standard fertility, was coming to an end. Especially was attention directed to this when Sir William Crooks, in his address as President of the British Association in 1898 said, "Practically, there remains no uncultivated prairie land in the United States suitable for wheat growing."[3]

The marginal producer who sets the price has, in recent years advanced onto progressively inferior soils and this progression of inferiority has apparently been rapid since 1900, as may be seen from the large migration of farmers which soon started for Canada, and from the rise in western farm values which ranged from 50 to 100% between 1900 and 1905.[4] Since 1905 an almost equal advance has been made, so that lands in the corn belt which were $100 per acre are $250 and are too valuable to be used for cattle raising. By these advances

[1]Corn, wheat, rye, cotton, bacon, ham and mess beef for export illustrate this.
[2]In 1904 sharp upward turn for wheat and rye, 1901 for corn, beef, bacon and ham, 1907 for oats.
[3]C. Wood Davis and John Hyde of the Dept. of Agriculture substantially agreed with Crooks.
[4]Holmes in Year Book, Dept. of Agr. 1905, p. 514.

in the price of standard farm lands we may obtain a rough measure of the inferiority of the margin. The agricultural literature of a scientific character which has been issued in the last few years clearly indicates where the warfare of science is being waged in behalf of the marginal farmer. This literature is full of discussion of the problems of the worn-out fields of the South; the under-drained lands of the North; of dry farming in the Great Plains, of irrigation farms in the Intermountain regions; and of the transportation problems of remote districts. These are our margins of cultivation.

It is probably true to say that agricultural operations have been less bound by cost limits and by competition than most other industries. The cost of production is difficult to ascertain and the American farmer, hitherto, has not been driven to determine it exactly, because the chief source of difficulty is the relation of any process or product to the reserve of fertility in the soil. It seems to me clear that during the nineties many crops were marketed for less than the cost of production, and that the sharp rise in land values in the early nineties and again in recent years has attracted the attention of the farmer to the relation between income and investment, and to the relation between the system of farming used and the permanence of his capital in the soil. This has been reenforced by the "conservation" movement and by the influence of the "experiment stations" to which the farmer has been obliged to apply for guidance in fighting plant and animal diseases and insect pests. Out of this has come a well-defined movement to change the style of farming in such a manner as to secure better soil treatment. It is as a consequence of this that prices have been moving upwards. They are passing from the levels of an exploitive process to those of a permanent conservative type of farming in which the fertility of the soil will be maintained.

It may be objected at this point that a conservation movement ought to increase the number of cattle, sheep and swine on American farms, whereas their number has declined between 1901 and 1910 from 179 million to 174 million. This would have been true a few years ago, but since the function of leguminous crops has become better understood the farmer has found that the growing of a crop to plow under is a less laborious method of renewing his nitrogen than the handling of cattle.

Another farming cost which must be allowed for is farm labor. This has increased because of the necessity of paying an increased premium to induce people to live and work in the country where land is so high that they cannot hope to become proprietors, and where they must deny themselves the attractions of city life which have undoubtedly increased much in a generation. Furthermore the immigrants now coming to us from south-eastern Europe recruit the farming class less than did those from Germany and Scandinavia.[1]

Distributive Expenses.

When we turn to the distributive or marketing expenses which intervene before an agricultural product is transferred to the household of the consumer we have thrust upon our attention the physical fact that the centers of population and of farm area have been drawing apart

[1]Hall, "Immigration," pp. 42, 50, 56, 63, 66 with reference to Greeks, Italians, Hebrews, Syrians, Armenians, Stovacs, etc.

rapidly since 1880.[1] At that time these centers, as computed by the census, were about 200 miles apart. In 1890 they were 260 miles from one another, and in 1900 this distance was 385 miles. Something of the effect of this has been offset no doubt by improvements in transportation. This does not tell the whole story of course. The first development of western agriculture was close to the rivers and the lakes. Later the industry moved into regions where the effect of these avenues of cheap transportation was less.

A distributive expense of great importance is the modern advertising campaign. Although I am willing to grant what the business man says about the necessity of advertising for his individual business it is true in my opinion that advertising is one of the great blood-suckers of modern industry. Very largely it is a waste of money so far as the customer is concerned, as it is merely a usurpation by the manufacturer of the function of recommending and guaranteeing products which previously the local retailer performed. And in the change there is a waste, for the retailer is still necessary and the manufacturer must spend immense sums to gain the attention of the customers, a thing which the retailer has without expense in connection with shopping. Mr. Wiley of the Department of Agriculture recently said in Chicago that the cost of a bushel of wheat sold to the customer in the form of a well advertised breakfast food was $10.00. The statement of a prominent breakfast food manufacturer shows that over 30% of the cost to the consumer is manufacturer's advertising, and 10% more is involved in other manufacturer's selling expenses. And to this something should be added for the cost of doing business all over the United States in little quantities here and there wherever the national advertising campaign makes an appeal, and something for the expense to the grocers for carrying a large assortment of different brands of foods to satisfy the many small demands created by rival advertising campaigns.

Finally, on the subject of distribution, a word further may be said about the retail store. Possibly retail gross profits are less than they were during the days of the Granger agitation in the latter sixties and early seventies.[2] But it would be difficult to ascertain it, because most of the high profit goods of today are either entirely new or could not be directly matched with articles offered in the seventies. When we think of economical retailing we naturally think of the department store, but this agency which is economical when not conceived on too luxurious a plan applies in a very small degree to food distribution. Foods are distributed, as are drugs and drinks, by neighborhood convenience stores. Grocery stores and meat and bakery shops must make small sales and numerous deliveries because the city family has small storage space, uses expensive ice, and the cook is not expert in the Continental art of recooking. These deliveries are not only expensive but there is involved in them the circumstance that when a customer's purchases are numerous and small and chiefly delivered it is out of the question to get cash payment for each purchase, so that a large sum is constantly tied up in credit advances. For these reasons such stores are distributed to residence districts and are small and uneconomical. The number of such

[1] In 1870 the distance between them was 185 miles.

[2] 1867-1876 covers the activity of the Grangers and Sovereigns of Industry.

shops is atrociously redundant because the modern housewife has not the disposition to go long distances to market and because the capital required to enter the business is moderate and the division of labor in a small store is not sharp enough to prevent every clerk from picking up enough knowledge to presently strike out for himself. In addition to these unfavorable circumstances the shopper, accustomed to department store methods, is exacting in matters of stock and equipment, so that the line of least resistance in competition is often to divide the trade and refine or elaborate the service rather than to offer lower prices.[1]

New Wants.

Turning from the production and distribution of agricultural staples to the new wants which have established themselves in a generation we must, at the outset, recognize that the growth of these wants is not only due to increased earning power of the consumer, but to the thirty years of low-priced staples, which have left free an unusually large portion of his earnings to be expended on other things.

Among these wants permit me to single out three groups involving respectively the dietary, the household economy, and expenditures of chiefly social import.

The dietary changes of forty-five years have been marked. They involve an increase in the consumption of sugar, milk, butter, poultry, fruit and vegetables. Most of these changes have been toward foods more pleasing to the palate but of low nutritive value, such as cucumbers, melons, salads, green vegetables, strawberries, tomatoes, olives, canned goods, oysters, etc. Peaches in good condition contain 8% solid matter; milk contains 13% of solids; fruits generally are from 85 to 90% water.[2] Such foods have therefore relieved the demand for the staples but little.

The beginnings of a general demand for these expensive foods may be traced to the decade following the close of the Civil War, and appear to arise as a function of the decline in the price of the staples. For example, it was cited as a wonderful thing in 1865 that Cincinnati sent fruits to the lake cities two weeks before the northern season opened, and that the latter localities sent back late fruits. In 1866 the district in southern Illinois known as "Egypt" began to be developed for early fruits and vegetables, and in connection with its transportation problem the refrigerator car, invented in 1868 by Davis and Sutherland of Detroit, was perfected. In 1870 the California fruit industry began a long period of rapid growth, first to supply canning and drying establishments, but after the early eighties to supply shipments of fresh fruit to the east in refrigerator cars. In 1875 there was developed something of a craze with reference to the Florida orange industry and families moved from all sections of the country to that state. In succeeding years Florida sent early fruit, and vegetables in ever increasing variety to the eastern cities and from her and California the southern states generally have learned the profit of supplying the early markets.

At the present time these industries have reached a very large development. The first strawberries, from Christmas until the middle of February come from Florida and Texas, then the Gulf states and North Caro-

[1]Sec. Wilson has found that the cost of retailing meat in 50 cities is 38%, calculated on wholesale prices. Report, 1909.

[2]Lazenby in Ohio Hort. Soc. Proc., 1900.

lina provide the supply until May when Tennessee, Virginia, Maryland and Southern Illinois supply us. The supply of fresh eggs comes from the same regions in about the same order, but a month earlier. In the vegetable trade Florida holds the seaboard until Easter while Texas and Louisiana supply the west, and the supplying regions move north with the progress of the ripening belt.

These are out-of-season industries, so far as the northern farmer is concerned, and by their development we have pushed the supplying districts away from us. The natural correlation by which truck and fruit farms locate around the cities they supply has been disturbed and we buy foods three-fourths of the price of which is middleman's profits and transportation. The Deland (Fla.) News has recently said that even for so standard a crop as oranges the northern wholesale price is from one-third to one-half freight.

Household economy.

Another group of wants has arisen in connection with changes in the household economy. There were three times as many people living in American cities in 1900 as in 1870[1] and they lived in larger cities. This fact alone involves far-reaching consequences. The cost of preserving health, privacy, and the decencies of life in cities is a figure we are beginning to explore in connection with the warfare now made on disease, and in payments for plumbing, water, insurance, local transportation, sidewalks and streets and taxes. The necessities of city life have forced many industries out of the households and the growth of factory production has attracted others. A good deal of the baking, canning, curing of meats, manufacture of clothes, carpets, soap, etc., has been removed along with the preparation of the winter wood and the care of the vegetable garden. The change is no doubt desirable, taking it as a whole. It saves the labor of women and children and of the after-work hours of the wage-earner, but as this labor is usually not marketed in any other form new items of cash expenditure must of necessity appear in the family budget.

By this change the household is made less of a training school than it once was and, as the teaching of domestic science has not yet been generally introduced, young women of today know less than their mothers about such tasks as still remain in the household, and they are less habituated to withstand the drudgery of difficult or tedious duties. So there is a great demand for ready-prepared foods. The housewife who does not know how to cook or who desires to avoid the complex processess by which cheap meats can be made palatable, or who has a servant equally anxious to avoid this work, must buy tender and expensive cuts. Nor can a shopper who is ignorant of qualities expend money efficiently. She must fall back upon price as the criterion of excellence, and is likely to become the prey of the maker or dealer who maintains the most expensive advertising campaign to "educate" her.

Expenditures of Social Significance.

In conclusion, a word about expenditures which have an important bearing upon social standing. So long as the splendid descendants of the Puritans in New England and of the F. F. V's. in Virginia lived together in poverty in their eastern homes there was a definite and in-

[1]In 1870—8,071,875 or 20.9%. In 1900—24,992,199 or 33.1%.

fluential element in American national life which stood for "plain living and high thinking." But since the sons and daughters of these families have moved west, and in the majority of cases become affluant, there is reason to fear that the element just referred to has become more or less lost in the multitude of the merely rich. These western sons and daughters, if they have contributed any influence, have done it by so combining wealth and refinement as to cast doubt upon the exclusiveness of the relation of "high thinking" to "plain living." And so a relaxation toward luxury is a characteristic recent national tendency.

There are some matters of a more technical character which may be dwelt upon for a moment. People judge each other by all kinds of tests. In the lumber camp the best chopper is an aristocrat. In an agricultural neighborhood the farmer with the largest farm or the biggest barns may be so. Where the process of wealth production is tangible, mastery of it is likely to be given weight in the determination of positions in the social scale. In modern society where the labor of so many men is labor of the mind alone and where through the existence of corporations the property connections of individuals are difficult to trace, the tendency is increased to judge people by the manner and the amount of their expenditure rather than by their characteristics as producers of wealth. As everyone is anxious to stand well in the opinion of his fellowmen the tendency of this is obvious. The brain workers in corporate relations are not a large class to be sure, but then they are important in setting the tendencies.

The conditions of city life intensify comparisons of a materialistic sort. The very neighborhood in which one lives is classified on the basis of the value of the real estate, and the typical city list of calling acquaintances must quickly judge by the tangible means most ready at hand.

I have spoken of the partial emancipation of woman from household drudgery. The leisure thus produced has in part been devoted by her to such elaboration of the art of living as has quite naturally called for increased expenditures here and there, and in this she has been efficiently aided by magazines and newspapers which now familiarize each class in society with the manner of living of other classes as never before.

It may be an error to say that we have come into a period of years which will prove a turning point in our national civilization but it is difficult to imagine any economic reaction more fundamental than that between a nation and the land upon which it lives. If we are really through with the easy expansion of our agriculture, as the population increases we shall need to review our entire national economy and eliminate wastes rather than give up precious utilities. There is the cost of two or three hundred thousand unnecessary retail stores, the cost of a considerable part of our advertising, the cost of fire losses, the cost of doing without a reasonable element of vocational training in every man's education, the cost of violating the principles of conservation, and many other great wastes which are a part of the economic problem of reorganizing our industries and our habits of consumption, which will be thrust upon us if we are passing out of the pioneer stage into that of a mature national economy.

Ann Arbor, April, 1910.

SOME OBSERVATIONS ON RECENT AMERICAN ECONOMIC THINKERS AND THEIR THOUGHT.

LEWIS H. HANEY.

I.

From the beginning the peculiar environmental conditions met with in America have given a characteristic set of tendencies to American economic thought.[1] In the first place the point of view tends to be optimistic. The country is young and the resources boundless. It has been in the "advancing state" of the old economists. In accordance with this general tendency, from early times to Patten there has been another tendency to deny the validity of the classical law of diminishing returns, and yet another to attack the Malthusian doctrine of population.

Being in a progressive or "advancing" state characterized by speculating fluctuations in price, etc., the dogma of equalized wages and profits has functioned little as a premise in American thought. The great variations in expenses and prices as between different points within the vast area of the United States, especially in earlier times, must likewise have operated in this same direction.[2]

Again the fact that farms have been "carved out" of the wilderness before our very eyes has suggested the question, is land not capital? The abundance of land, moreover, has, in connection with a democratic people, begotten a system of land ownership which has made the distinction between land and capital less obvious than in a country like England. Accordingly we find Carey holding heterodox views on this point, and a strong tendency in a similar direction appears today. Americans have been forward in applying the differential idea to labor and capital as well as land.

The relative scarcity of labor and capital which has existed well down to date has also found its expression in certain theoretical peculiarities,—in addition to furthering the one just noted. For one thing the necessity for and importance of the management factor has been accentuated. Invention, too, has been stimulated and its importance emphasized. This has fostered a point of view in which change and progress are regarded as normal.

But most interesting of all is the suggestion that the common acceptance of the marginal productivity theory of distribution may be an offspring of a national psychology engendered by these conditions. Where labor, for example, is scarce and relatively independent the wages fund doctrine would hardly be suggested, while it would be easy to conceive a relationship between productivity and income. Some of the assumptions in Professor Clark's theorizing have been actualities in America. There has been a great deal of free, no-rent land, upon which the settler put his labor. If he could get it, hired labor was

[1]See Sherwood, "Tendencies in American Economic Thought," Johns Hopkins University Studies, 1897.

[2]See Leslie, Essays in Pol. and Moral Philos., p. 137f.

paid all that it was "worth" and the subsistence wage has been far less common in America than in Europe. Labor was the factor which had to be economized, rather than land, and *its* productivity was scrutinized. The result was a productivity theory, and the application of the differential idea, or an echo from one of the numerous early writers who suggested the marginal concept for value determination, completed the scheme. But oftentimes in the earlier days capital was the scarcest of all, when like results might be expected for interest theory.

Nor is it unlikely that the readiness with which certain of our theorists take to the idea of capital as a mobile fund, criticising the idea of capital as the aggregate of capital goods, has been furthered by the prevalence of corporations and speculation and the relative mobility of investment, taken together with the preceding conditions.

Finally, America's relative isolation has made her a stanch protectionist country. Located remote from the old centers of arts and industry, and at a time when the products of manufacture were of great importance, the "American system" according to which ocean freight charges were to be saved and home markets developed, was a natural consequence. America, directly and through List, has been the center of the modern protectionist idea.

Of course these "tendencies" do not find equal expression in all our economists, and there have always been some who have upheld the classical doctrines; but our most characteristic ones will always be found to illustrate the reality of them sufficiently well.

With this background in view let us turn to briefly examine some of our recent economic thinkers and their thoughts.

II.

Perhaps to some extent on account of the comprehensiveness of the American Economic Association, it seems that there is no such division into important schools as is the case in Germany, for instance. Or the fact may be due in part to the later development of activity in economic thought. Coming after the reaction against extreme *historismus* has set in, there was less occasion for the schools involved. Moreover the absence of so widespread and acute a condition of class antagonism and the evils accompanying it may explain in part the slight importance of socialism to date. It is characteristic of American economics that there is relatively little difference of opinion as to the tariff and government control, neither being entirely condemned.

On the whole there are but two great groups with so many variations within both—and so shading into one another—that they cannot be called schools. One holds to a large part of the teaching of Mill; the other follows the Austrian school and Professor Clark. Accordingly there is on the surface at least wide difference in the importance attributed to cost in value determination, in the theory of interest, and in the treatment of land and the return from land. To mention but a few names: Professors Clark, Patten, Fisher, and Fetter are inclined to emphasize the subjective point of view and the utility side of marginal utility, and to deny the significance of the classical rent doctrine; Professors Ely, Carver, Bullock, Taussig, and Laughlin would lay more emphasis on costs and hold to an enlightened Ricardian doctrine of rent.

Professor Fisher of Yale is the leading exponent of the mathematical method. As statisticians Mayo-Smith and Wright,—now deceased,—Dewey, Willcox, and Bailey are among the best known Americans of recent times.

There can be no doubt of a strong tendency among American economists to emphasize psychological analysis. After 1885 the thought of Jevons and the Austrian school took firm hold, and American economics has come to its recently acquired place of prominence largely through independent development of parts of this field. Accordingly it is probable that three of our four or five leading theoricians are Clark, Patten, and Fisher.

Professor John Bates Clark is admitted by many to be the greatest constructive general theorist that America has yet produced. His claim to some originality in developing the significance of marginal utility is strong and his name will ever be associated with the marginal productivity analysis in static distribution. Many of the most promising of the younger economists have been much influenced by him, and while several of his main ideas are accepted by few, his calm, clear analysis has been very suggestive and has done much to clear up distribution problems.

It is not unlikely that Clark received some stimulus from Bastiat, and he himself refers to the influence of Henry George.[1] He must also have gathered ideas from Jevons and the Austrians. For the rest, he fell under the sway of the idea, current among sociologists and economists of the historico-sociological type, that society is an organism. Add to this background Professor Clark's great power of sustained abstract speculation and we have some of the chief factors in his work.

In his *Philosophy of Wealth* (1885) the two main ideas are that the prevalent theory of value misconceived the part played by utility, and that society is an organism to be treated as a unit in discussing processes of wealth distribution. Clark distinguishes absolute from effective utility, defining the latter as "power to modify our subjective condition, under actual circumstances, and....mentally measured by supposing something which we possess to be annihilated, or something which we lack to be attained."[2] Market value is measured by this utility estimated by society considered as one great isolated being.[3]

Clark also emphasized the limits set to competition in modern society, appealing to a more rational means of effective distribution.

It is by his *Distribution of Wealth*, published in 1899, that Clark is best known. Put in a nut shell it is the idea of the book that in a "static" condition the factors of production receive shares corresponding to the productivity of their final or marginal increments, the process being "controlled by a natural law."

The social viewpoint being taken, and society being regarded as an organism, it follows that distribution and exchange—with value—are included in the round of production. Distribution has three stages: the division of social income, first, among various groups of industries, then among sub-groups, and finally among the factors of production within

[1]Distribution of Wealth, preface, p. VIII. George's idea that wages are fixed by the product which a man can create by tilling no-rent land.
[2]P. 78. Compare Distribution of Wealth, p. 376. This statement is subject to the same criticism as is Menger's.
[3]P. 82.

the sub-group. The first two processes are controlled by the market price of the produce: the last, or functional distribution, as we would say, is governed by productivity, labor tending to get what it separately produces and capital likewise.[1]

In order to reduce all units to homogeneity Clark would fund all the factors of production. Land and capital are reduced to an abstract mobile capital fund ("social capital"), and labor to productivity units ("social labor"). Then the specific product of a unit of any factor may be segregated, he maintains, by turning to the margin. In the case of labor this may be found widespread in a zone of indifference as to employing more men. In all industries there is an intensive margin.

It is a chief service of Clark to have developed and defined (not originated) the idea of a fund of value abstract and not lost in the capital goods through which it finds expression at any given time. This is similar to the business usage. It is a conception which helps to an understanding of the mobility of capital under competitive conditions. The criticism is that Clark carries the idea too far, applying it to factors which are not mobile in fact.

Though for the most part a "natural" tendency to equalize returns in different industries is posited as the force assuring the productivity correlation, it is made clear that it is the free competition among employers that is assumed in the static state which insures the full value of his product to the laborer. The pleasure and pain calculus is the mainspring of the whole machine.

Both wages and interest can be "translated" into the form of rents on concrete producer's goods—Clark denies peculiar significance to land rents—and these rents are elements in determining values.

Professor Clark's theories have been attacked on all sides.[2] Relatively few are in agreement as to the organic character of society, and few believe that such "heroic abstraction" as characterizes his theory is fruitful. His "static state" is after all quite similar to one in which the "natural" conditions thought of by the classical economists exist. Hobson and others have attacked the validity of the "dosing" method of isolating the specific product of a given factor. Others deny that land can be treated as a mobile fund, holding that in this it differs from capital. Perhaps the basic weakness of Clark's analysis is similar to that found in the thought of the Austrian school, namely, the fact that it attempts to apply to a complex of individuals, society, a marginal-utility analysis which can hold only for the individual.

We must not think, either, that in some measure to justify a static tendency as to functional distribution is to justify the present social order. For even though units of labor and capital each received a return proportional to its productivity there would still remain the personal question, does each laborer receive what *he* produces? Or, again, the mere fact that the land owner receives what his land produces does not justify private property in land.

In his more recent *Essentials of Economic Theory* (1907) Clark in no way departs from his old stand. The distinction between static and dynamic is ever before us and though the book is written partly to ful-

[1]Chapter II.

[2]See e. g., Carver's and Hobson's discussion in the Journal of Political Economy, 1904-05; Carver's discussion in Quarterly Journal of Economics, August, 1891; Davenport's Value and Distribution, Chapter XXII.

fill the author's promise to develop dynamic laws, his static laws loom large in the background. Whatever prevents the working of static laws—that is, free competition—should be regulated. The thought processes are stimulating, but the book contributes nothing to economic essentials.

A disciple of Professor Clark, Alvin S. Johnson, has recently published an *Introductory Economics* (1907) which is harder-headed and less open to the above criticisms that the work of his master. Wieser's theory of value is admirably adapted, but cost is given an important part in determination; and though land is included under capital goods, its peculiarities are emphasized and the fact that the recent disputes over the place of land really rest upon the distinction between capital funds and capital goods is plainly apparent.

Professor Simon N. Patten is one of the most unique economists America has produced. But his genius is erratic—almost perverse. Patten's chief economic writings are *Premises of Political Economy* (1885), *The Consumption of Wealth* (1889), *Dynamic Economics* (1892), and *The Theory of Prosperity* (1902). To briefly indicate some of his characteristic doctrines: he has developed the idea of the importance of consumption, making changes which adapt it to environment a factor in reducing costs as men progress; he is optimistic, denying the existence of a law of diminishing returns; to him the shares in distribution are price-determined, costs cutting no figure; and in order to harmonize the idea of increasing demands with that of increasing returns monopoly is made normal and given a large part.[1] The ideas of alternative use and opportunity costs find frequent expression. Patten has pointed out that land once brought under cultivation will not be abandoned exactly at the point where returns just fail to cover cost, but that production will be carried further.

Professor Patten's main ideas underlie the more recent "Economics" by Nearing and Watson,—a crude but stimulating text.

Professor Irving Fisher has summed up his economic theories in two recent volumes: *The Nature of Capital and Income* (1906), and *The Rate of Interest* (1907). It does not seem that these books can be classed with the works of Clark and Patten in so far as *additions* of fundamental importance to economic theory are concerned. The writer reasons clearly. By adopting the accountant's viewpoint he has shed some new light,—though his writings do not escape illustrating the difficulty of adopting a new terminology. The Austrian idea is the dominant one: the value of capital goods, including land, is the discounted value of their income. And a point upon which much stress is laid is that income must not be confused with the material objects (capital) which afford it, but consists of the services rendered. The interest rate, the determination of which Fisher would make the chief problem of Economics, depends upon the "time preference" of individuals for present over future goods,—an "agio" theory.

[1] "The motives for production increase as wants grow in intensity; but costs fall off with the growth of productive power, thus destroying the equality between it and the return in goods. A new equilibrium is created on the market by the equality of marginal expense and marginal utility. Wants grow more rapidly than productive powers: values rise, and producers gain a monopoly power equal to the difference between cost and the expense of goods. Monopoly is thus essential to a market equilibrium and the monopoly fund has its size fixed by the natural excess of demand over supply. Intense wants and low costs of production have no other means of equating themselves." Theory of Prosperity, p. 234.

To one thinking as the writer does, Professor Fisher, while criticising others for making question-begging assumptions, has made his own statement of the case one-sided by a similar error. By slighting costs and objective limitations his "time preference" becomes a mere assumption; and he takes income for granted when he criticises cost theories (*Rate of Interest*, pp. 33, 44, 46).

Quite different from the foregoing are the views of Professor T. N. Carver, who perhaps best represents the great body of the less radical of the American economists. In his *Distribution of Wealth* (1904) he calls a halt to the one-sided emphasis of psychology and points to the economic environment factor. The book contains a noteworthy restatement of the law of diminishing returns and an able criticism of the Austrian ideas on interest, which is applicable in a great degree to Fisher and Clark. He makes the law of diminishing returns universal and not confined to land only. If to a limited quantity of any factor increasing quantities of other factors are added a time will come when the return diminishes relatively to the quantity added. As to the interest question. To Carver the question is, "Why is the income more than sufficient to keep the supply of capital intact, or to replace it * * *?" Cost and productivity are synthetized as in the case of value determination. Unless the supply of capital was in some way limited its marginal productivity would disappear and these limits are the cost of making capital goods and the sacrifice of waiting, including an element of incalculable risk.

There is a sense, Carver holds, in which rent does not enter price as wages do; for land is separable from the owner and does not have to be persuaded to work by any offer of advantage (p. 207).

Furthermore, Professor Carver lays more emphasis upon the Malthusian theory of population in connection with the theory of wages than do the preceding writers.

III.

When one turns from an extended reflective examination[1] of the numerous recent treatises on Economics one feels like raising the question, whither are we tending?—and is tempted to make some generalizations along that line. Yielding to this temptation the writer would conclude with a few rather hasty generalizations, hoping that they may at least provoke discussion.

1. Looking back some fifty years, there appears to be a tendency to return to a general, "pure" Economics. Beginning say with J. S. Mill there came a tendency to bring in all manner of social and ethical data. Later, a mass of technical data has been worked over; and, on the other hand, psychological and philosophical materials have been heavily drawn upon. But now Political Science and Government, and Sociology are splitting off; and with technical courses springing up, and Ethics enriched by economic infusions, we are ready for a more well-rounded body of pure economic principles.

2. It seems not unlikely that there is and will be a concomitant growing distinction between public and private economics. The growth

[1]It has not seemed well to include in the preceding observations the detail and repetition which would be involved in making them the full basis for the following generalizations.

of courses and literature along the lines of private finance and semi-technical commercial subjects points this way.

3. Perhaps not without connection with the preceding point is the growing emphasis of the distinction between the social and the individual or entrepreneur viewpoints,—a distinction for the lack of which certain older writers fell into confusion in their value theories. It does not seem to the writer that the current talk about the entrepreneur viewpoint, opportunity cost, etc., can serve as the basis for the theory of value in political economy.

4. Within the domain of pure public economics a reaction against the excessive attention to psychological factors is bound to come, or is at hand. With the lowering of production margins and the increasing realization of certain objective limitations which now seem likely in this country, this reaction will come the quicker. The fundamental character of the opposition between man and his natural environment will not down.

5. Accordingly the marginal utility mist is being cleared up. Even the plea that this phrase is a convenient way of putting the forces back of demand and supply together is being questioned. While nowhere finally dealt with, certain writers like McVane, Davenport, Bonar, Carlile, Landry, Dietzel, and Bortkiewicz have sapped the somewhat specious pretensions of the doctrine. We no longer regard it as an ultimate touchstone for all value questions,—as a means of expressing changes in a man's valuation of goods in terms of utility considered as a property of the goods.

6. In the field of capital and interest the writer is struck with the necessity of fighting out the questions which concern the nature of capital. The issue is being joined over the definition of capital as an abstract mobile fund. If this is its true nature then any object in which it may be imbodied may be a capital good. Moreover costs may be neglected. But if the true concept is that of an aggregate of capital good, costs come to the fore, and the peculiar significance of land rent appears.

7. Finally a minor point in recent tendencies concerns the development of accountancy and the application of accounting methods to economic analysis. From this much is to be hoped for in the direction of accuracy and completeness.

Ann Arbor, Mich., April 1910.

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Imperial Moskofskoie Obshchestvo Iestestvo-Ispytatelei; Moskow, Russia.
Imperial Sankt-Peterburgskoie Mineralogicheskoie Obshchestvo; St. Petersburg, Russia.
Imperial University of Tokyo, Library; Tokyo, Japan.
Indiana Academy of Science; Indianopolis, Ind.
Indiana Geological Survey; Indianapolis, Ind.
Indiana University Library; Bloomington, Ind.
Inspectorate General of Customs, Statistical Department; Shanghai, China.
Institute of France; Paris, France.
Institute des Mines; St. Petersburg, Russia.
Institute Luxembourgeois, Section des Sciences Naturelles; Luxemburg, France.
Institute of Jamaica; Kingston, Jamaica.
Institute Royale de la Suéde; Stockholm, Sweden.
Istituto Historico, Geographico y Etliynographico; Rio de Janeiro, Brazil.
Institution of Civil Engineers; Great George St., London, England.
Iowa Academy of Science; Des Moines, Iowa.
Iowa Geological Survey; Des Moines, Iowa.
Iowa University Library; Iowa City, Iowa.
Iron Mountain Carnegie Library; Iron Mountain, Michigan.
Istituto Geografico Militare; Florence, Italy.
Istituto Scientifico della R. Universita; Rome, Italy.
Jackson Public Library; Jackson, Michigan.
Jagellonische Universitaet, Bibliothek; Karkau, Austria-Hungary.
Jenaische Zeitschrift fuer Medicin u. Naturwissenschaften; Jena, Germany.
John Crerar Library; Chicago, Ill.
Johns Hopkins Press; Baltimore, Md.
K. Bayerische Botanische Gesellschaft; Regensberg, Germany.
K. Boehmische Gesellschaft der Wissenschaft; Prag, Austria-Hungary.
K. K. Deutsche Karl-Ferdinand Universitaet, Bibliothek; Prag, Austria-Hungary.
K. K. Geographische Gesellschaft; Wien, Austria-Hungary.
K. K. Geologische Reichsanstalt; Wien, Austria-Hungary.
K. Leopoldinisch-Caroloninische Deutsche Akademie der Naturforschen; Halle-an-der-Saale, Germany.
K. K. Leopold-Franzens Universitaet, Bibliothek; Innsbruck, Tirol, Austria.
K. Magyar Természettudományi Társulat; Tarsulat, Austria-Hungary.
K. K. Universitaet, Bibliothek; Wien, Austria-Hungary.
K. K. Zoologisch-Botanische Gesellschaft; Wien, Austria-Hungary.
K. Zoologische Genootschap "Natura Artis Magistra"; Amsterdam, Netherland.
Kais Universitaet Bibliothek; Kasan, Russia.
Kaiser-Wilhelms-Universitaet, Bibliothek; Strassburg, Germany.

Kaiserliche Universitaet, Bibliothek; St. Petersburg, Russia.
Kansas Academy of Science; Topeka, Kansas.
Kansas State Historical Society and Department of Archives; Topeka, Kansas.
Kansas University, Geological Survey; Lawrence, Kansas.
Kantonale Universitaet, Bibliothek; Bern, Switzerland.
Kentucky State College, Agricultural Experiment Station; Lexington, Ky.
Kjbenhavns Universitet Bibliothek; Kopenhagen, Denmark.
Kongl. Albertus Universitaet, Bibliothek; Koenigsberg, Prussia, Germany.
Kongl. Alexanders Universitetet I Finland, Bibliothek; Helsingfors, Finland.
Kongl. Bayerischen Ludwig-Max.-Universitaet; Munich, Germany.
Kongl. Christian-Albrechts Universitaet; Kiel, Germany.
Kongl. Eberhard-Karls-Universitaet, Bibliothek; Tuebingen, Germany.
Kongl. Frederiks Universitet, Bibliothek; Christiana, Norway.
Kongl. Friedrich-Alexanders Universitaet, Bibliothek; Erlangen, Bayern, Germany.
Kongl. Friedrich-Wilhelms Universitaet, Bibliothek; Berlin, Germany.
Kongl. Julius-Maximilians Universitaet, Bibliothek; Wurzburg, Germany.
Kongl. Karolinska Universitetet, Bibliotheket; Lund, Sweden.
Kongl. Ungarische Universitaet, Bibliothek; Budapest, Hungary.
Kongl. Universitaet, Bibliothek; Breslau, Germany.
Kongl. Universitaet, Bibliothek, Greifswald, Germany.
Kongl. Universitaet; Muenster in Westfalen, Preussen, Germany.
Kongl. Universitetet I Upsala, Bibliothek; Upsala, Sweden.
Kongl. Zoologisches Institut, Friedrich-Wilhelms Universitaet; Berlin, Germany.
Kongliga Svenska Vetenskap Akademien; Stockholm, Sweden.
Laval University Library; Quebec, Canada.
Leeds University Library; Leeds, England.
Leland Stanford University Library; Stanford University, Cal.
Linnean Scientific and Historical Society; Lancaster, Pa.
Linnean Society of London; Burlington House, W., London, England.
Linnean Society of New South Wales; Sydney, New South Wales.
Linnean Society of New York; New York City, N. Y.
Literary and Scientific Society; Ottawa, Canada.
Liverpool Geological Society; Liverpool, England.
Liverpool University Library; Liverpool, England.
Lloyd Library; Cincinnati, Ohio.
London School Board; London, England.
McGill University Library; Montreal, Canada.
Magyar Ornithologiai Koezpont; Budapest, Austria-Hungary.
K. Magyar Természettudományi Társulat; Budapest, Austria-Hungary.
Maine University Library; Orono, Maine.
Manchester Geological Society; Manchester, England.
Manchester University Library; Manchester, England.
Manila University Library; Manila, Philippine Islands.
Manitoba Historical and Scientific Society; Winnipeg, Manitoba, Canada.

Manitoba University Library; Winnipeg, Manitoba, Canada.
Marine Biological Laboratory; Wood's Holl, Mass.
Maryland Geological Survey; Baltimore, Md.
Massachusetts Board of Cattle Commissioners; Boston, Mass.
Massachusetts Horticultural Society; Boston, Mass.
Medicinische Naturwissenschaftliche section des Siebenbuergischen Museum Verein; Klausenburg, Austria-Hungary.
Melbourne University Library; Melbourne, Australia.
Michigan Agricultural College Library; Agricultural College, Michigan.
Michigan College of Mines Library; Houghton, Michigan.
Michigan State Normal Library; Marquette, Michigan.
Michigan State Normal Library; Ypsilanti, Michigan.
Milwaukee Public Museum, Milwaukee, Wis.
Minister of Public Instruction; Paris, France.
Minnesota Academy of Natural Science; Minneapolis, Minn.
Minnesota University Library; Minneapolis, Minn.
Missouri Botanical Garden; St. Louis, Mo.
Missouri Bureau of Geology and Mines; Rolla, Mo.
Missouri University Library; Columbia, Mo.
Montana University Library; Messoula, Montana.
Museo Civico di Storia Naturale; Trieste, Austria-Hungary.
Museo Nacional; Montevideo, Uruguay.
Museo Nacional de Buenos Aires; Buenos Aires, South America.
Museu Paraense de Historia Natural; Para, Brazil.
Museu Paulista; San Paulo, Brazil.
Museum fuer Natur-u. Heimatkunde; Magdeburg, Germany.
Museum of Geology and Archaeology; Princeton, N. J.
Museum of Natural History; Springfield, Mass.
National Academy of Sciences; Washington, D. C.
National University Library; Athens, Greece.
Natural History and Philosophical Society; Belfast, Ireland.
Natural History Society; Exeter, New Hampshire.
Natural History Society; Montreal, Canada.
Natural History Society of Glasgow; Glasgow, Scotland.
Natural History Society of New Brunswick; St. Johns, New Brunswick.
Natural History Society of Northumberland; Newcastle-upon-Tyne, England.
Naturforschende Gesellschaft; Bamburg, Germany.
Naturforschende Gesellschaft; Basel, Switzerland.
Naturforschende Gesellschaft; Bern, Switzerland.
Naturforschende Gesellschaft; Gorlitz, Saxony, Germany.
Naturforschende Gesellschaft; Leipzig, Germany.
Naturforschende Gesellschaft in Luzern; Luzern, Switzerland.
Naturforschende Gesellschaft; Zuerich, Switzerland.
Naturforschender Verein; Bruenn, Austria-Hungary.
Naturhistorisch-Medicinischer Verein; Heidelberg, Germany.
Naturhistorische Gesellschaft; Hanover, Prussia, Germany.
Naturhistorische Gesellschaft; Nurnburg, Bavaria, Germany.
Naturwissenschaftliche Gesellschaft; Chemnitz, Saxony, Germany.

Naturwissenschaftliche Gesellschaft; St. Gall, Switzerland.
Naturwissenschaftlicher Verein; Bremen, Germany.
Naturwissenschaftlicher Verein; Frankfurt-an-der-Oder, Prussia, Germany.
Naturwissenschaftlicher Verein; Hamburg, Germany.
Naturwissenschaftlicher Verein; Karlsruhe, Germany.
Naturwissenschaftlicher Verein; Lueneburg, Prussia, Germany.
Naturwissenschaftlicher Verein; Magdeburg, Saxony, Germany.
Naturwissenschaftlicher Verein; Osnabrueck, Prussia, Germany.
Naturwissenschaftlicher Verein; Regensburg, Bavaria, Germany.
Naturwissenschaftlicher Verein fuer Saechsen u. Thueringen; Halle-an-der-Saale, Prussia, Germany.
Naturwissenschaftlicher Verein fuer Schleswig-Holstein; Kiel, Prussia, Germany.
Naturwissenschaftlicher Verein fuer Schwaben u. Neuburg; Augsburg, Germany.
Naturwissenschaftlicher Verein fuer Steiermark; Graz, Austria.
Nebraska University Library; Lincoln, Nebraska.
Nederlandsche Entomologische Vereeniging; Leiden, Holland.
Nevada University Library; Reno, Nevada.
New York Academy of Medicine; New York City, N. Y.
New York Botanical Gardens; Bronx Park, New York City, N. Y.
New York Public Library; New York City, N. Y.
New York State Library; Albany, N. Y.
New York State Museum of Natural History; Albany, N. Y.
Norges Geologiske Undersoegelse; Christiania, Norway.
Northampton Institute; St. Johns Street Road, London, England.
North Carolina Geological Survey; Raleigh, North Carolina.
North Carolina University Library; Chapel Hill, North Carolina.
North Dakota Experiment Station, Agricultural College; Fargo, N. D.
North Dakota University Library; Grand Forks, North Dakota.
Northwestern University Library; Evanston, Illinois.
Nova Scotian Institute of Science; Halifax, Nova Scotia, Canada.
Oahu College; Honolulu, Hawaii.
Oberhessiche Gesellschaft fuer Natur-u. Heilkunde; Giessen, Hesse, Germany.
Oberlin College Library; Oberlin, Ohio.
Observatorio do Rio de Janeiro; Rio de Janeiro, Brazil.
Oesterreichischer Reichs-Forst Verein; Wien, Austria-Hungary.
Ohio Mechanics Institute; Cincinnati, Ohio.
Ohio State Academy of Science; Page Hall, Ohio State University, Columbus, Ohio.
Ohio State Archaeological and Historical Society; Columbus, Ohio.
Ohio State University Library; Columbus, Ohio.
Ohio Wesleyan University Library; Delaware, Ohio.
Oklahoma University Library; Norman, Oklahoma.
Olivet College Library; Olivet, Michigan.
Onondaga Academy of Science; Syracuse, N. Y.
Ontario Minister of Education; Ottawa, Canada.
Oregon University Library; Eugene, Oregon.
Orto Botanico; Palermo, Italy.

Oschshestvo Iestestvo-Ispytalelei pri Imper. Kazanskom Universitetie; Kazan, Russia.
Oxford University Entomological Society; Oxford, England.
Peabody Academy of Science; Salem, Mass.
Peabody Institute Library; Baltimore, Md.
Peabody Museum of American Archaeology and Ethnology; Cambridge, Mass.
Pennsylvania Geological Survey; Philadelphia, Pa.
Pennsylvania University Library; Philadelphia, Pa.
Perthshire Society of Natural Science; Perth, Scotland.
Petermanns, Dr. A., Geographiache Mitteilungen; Gotha, Germany.
Petoskey Public Library; Petoskey, Michigan.
Phillips Academy, Department of Archaeology; Andover, Mass.
Philosophical Society of Glasgow; Glasgow, Scotland.
Popular Science Monthly; Sub-station 84, New York City, N. Y.
Portland Society of Natural History; Portland, Maine.
Princeton Academy of Science; Princeton, Ill.
Princeton University Library; Princeton, New Jersey.
Provinzial-Verein fuer Wissenschaft-u. Kunst; Muenster, Prussia, Germany.
Public Gardens and Plantations; Gordon Town, Jamaica.
Public Library; Bay City, Michigan.
Public Library; Traverse City, Michigan.
Public Library and Museum; Brighton, England.
Public School Library; Adrian, Michigan.
Purdue University Library; Lafayette, Indiana.
Queen's College Library; Belfast, Ireland.
Queen's College Library; Galway, Ireland.
Queen's University Library; Kingston, Canada.
Real Academica de Ciencias Exactes, Fisicas y Natureals; Madrid, Spain.
Real Academia de Ciencias y Artes; Barcelona, Spain.
R. Accademia delle Scienze e Belle Lettere; Naples, Italy.
R. Accademia di Scienze, Lettere ed Art; Padua, Italy.
R. Accademia di Scienze, Lettere Bell-Arti; Palermo, Italy.
Regia Superiore d' Agricoltura Biblioteca; Portici, Italy.
Regia Università degli Studi, Biblioteca, Bologna, Italy.
Regia Università degli Studi; Genoa, Italy.
Regia Università degli Naples, Biblioteca; Naples, Italy.
Regia Università degli Studi, Biblioteca; Padua, Italy.
Regia Università degli Studi, Biblioteca; Palermo, Italy.
Regia Universitá degli Studi, Biblioteca; Parma, Italy.
Regia Università degli Studi, Biblioteca; Pavia, Italy.
Regia Università degli Studi, Biblioteca; Pisa, Italy.
Rigia Università degli Studi, Biblioteca; Rome, Italy.
Regia Università degli Studi, Biblioteca; Turin, Italy.
Regio Istituto Veneto di Scienze; Venice, Italy.
Rheinische Friedrich-Wilhelms Universitaet, Bibliothek; Bonn, Germany.
Rijksuniversiteit, Bibliothek; Groningen, Holland.
Rijks Universiteit, Bibliothek; Leiden, Holland.

Rijks Universiteit, Bibliothek; Utrecht, Holland.
Rivista Argentina; La Plata, South America.
Rivista Italiana di Scienze Naturali; Siena, Italy.
Rochester Academy of Science; Rochester, New York.
Royal Astronomical Society of Canada; Toronto, Canada.
Royal Botanic Garden; Edinburgh, Scotland.
Royal Botanic Garden; Kew, England.
Royal Botanic Garden; Sibpur, Near Calcutta, India.
Royal Botanic Society; Inner Circle, Regents Park, London, England.
Royal Dublin Society; Dublin, Ireland.
Royal Geographical Society; London, England.
Royal Geographical Society of Australasia; Adelaide, South Australia.
Royal Geological Society of Cornwall; Penzance, England.
Royal Irish Academy; Dublin, Ireland.
Royal Istituto Botanico; Palermo, Italy.
Royal London Ophthalmic Hospital; City Road, E. C. London, England.
Royal Medical and Chirurgical Society; London, England.
Royal Microscopical Society; Kings College, W. C. London, England.
Royal Society of Arts; John St., Adelphia, London, England.
Royal Society of Canada; Ottawa, Canada.
Royal Society of Edinburgh; Edinburgh, Scotland.
Royal Society of New South Wales; Sydney, New South Wales.
Royal Society of Queensland; Brisbane, Queensland, Australia.
Royal Society of South Australia; Adelaide, South Australia.
Royal Society of Tasmania; Hobarton, Tasmania, Australia.
Royal Society of Victoria; Melbourne, New South Wales.
Saellskepet pro Fauna et Flora Fennica; Helsingfors, Finland.
Sage Library; Bay City, Michigan.
Saginaw E. Side Public Library, Saginaw, Michigan.
St. Andrews University Library; St. Andrews, Scotland.
St. Francis Xavier's College; Antigonish, Nova Scotia, Canada.
St. Louis Academy of Science, St. Louis, Mo.
San Diego Society of Natural History; San Diego, California.
School of Mines; Ballerat, Victoria, Australia.
Schweizer Entomologischen Gesellschaft; Bern, Switzerland.
Schweizerischer Forst-Verein; Zurich, Switzerland.
Scottish Natural History Society; Edinburgh, Scotland.
Seattle Public Library; Seattle, Washington.
Sheffield University Library; Sheffield, England.
Smith College Library; Northampton, Mass.
Smithsonian Institution; Washington, D. C.
Sociedad Agricola Mexicana; Mexico City, Mexico.
Sociedad Cientifica "Antonio Alzate;" Mexico City, Mexico.
Sociedad Cientifica Argentina; Buenos Aires, Argentine Republic.
Sociedad de Ciencias Fisicas y Naturales; Caracas, Venezuela.
Sociedade de Geographica; Rio de Janeiro, Brazil.
Sociedad Mexicano de Historia Natural; Mexico City, Mexico.
Sociedad Scientifica; San Paulo, Brazil.
Società Adriatica di Scienze Naturali; Trieste, Austria-Hungary.
Società Entomological Italiana; Florence, Italy.

Società Italiana delle Scienze; Rome, Italy.
Società Italiana di Scienze Naturali; Milan, Italy.
Società Toscana di Scienze Naturali; Pisa, Italy.
Societas pro Fauna et Flora Fennieca; Helsingfors, Finland.
Société Belge d' Astronomie; Bruxelles, Belgium.
Société Belge de Géographie; Bruxelles, Belgium.
Société Belge de Geologie; Bruxelles, Belgium.
Société de Bilogique; Paris, France.
Société de Botanique du Grand-Duché de Luxembourg; Luxemburg, France.
Société de Geographie; Toulouse, France.
Société des Naturalistes de Bessarbie; Kischinew, Russia.
Société des Sciences, Agriculture et Arts de la Basse-Alsace; Strassburg, Germany.
Société de Sciences de Nancy, Nancy, France.
Société des Sciences Historiques et Naturelles de la Corse; Bastia, France.
Société des Sciences Historiques et Naturelles de l'Yonne; Auxerre, France.
Société des Sciences Naturelles; Neuchatel, Switzerland.
Société des Sciences Naturelles; Versailles, France.
Société des Sciences Physiques et Naturelles; Zurich, Switzerland.
Société Entomologique de Belgique; Bruxelles, Belgium.
Société Entomologique de France; Paris, France.
Société Géologique de Belgique; Liege, Belgium.
Société Géologique de France; Paris, France.
Société d'Histoire Naturelle; Autun, France.
Société d'Horticulture et de Botanique; Havre, France.
Société d'Horticulture et de Botanique, Marseilles, France.
Société Linnéenne de Bordeaux; Bordeaux, France.
Société Linnéenne de Lyon; Lyon, France.
Société Linnéenne de Normandie; Caen, France.
Société Linnéenne du Nord de la France; Amiens, France.
Société Nationale des Sciences Naturelles; Cherbourg, France.
Société Royale de Botanique de Belgique; Bruxelles, Belgium.
Société Royale des Sciences; Liege, Belgium.
Société Royale Linnéenne de Bruxelles; Bruxelles, Belgium.
Société Scientifique de Bruxelles; Bruxelles, Belgium.
Société Scientifique de Chevtshénko; Lemberg, Austria-Hungary.
Société Zoologique de France; Paris, France.
South African Association for the Advancement of Science; Johannesburg, South Africa.
South African Journal of Science; Cape Town, South Africa.
South Dakota Geological Survey; Vermillion, South Dakota.
State Historical Society of South Dakota; Pierre, South Dakota.
Staten Island Association of Arts and Sciences; New Brighton, New York.
Sydney University Library; Sydney, New South Wales.
Tacoma Academy of Science; Tacoma, Washington.
Texas Academy of Science; Austin, Texas.
Texas University Library; Austin, Texas.

Tokio Imperial Museum, Department of Natural History; Tokio, Japan.
Toronto University Library; Toronto, Canada.
Torrey Botanical Club, Columbia University; New York City, N. Y.
Trenton Natural History Society; Trenton, New Jersey.
Trinity College Library; Dublin, Ireland.
Trinity University Library; Toronto, Canada.
Tufts College Library; Tufts College, Mass.
Ufficio Centrale Meteorologico e Geodinamico; Rome, Italy.
U. S. Department of Agriculture Library; Washington, D. C.
U. S. Geological Survey; Washington, D. C.
U. S. Naval Observatory Library; Washington, D. C.
U. S. Surgeon Generals Office-Library; Washington, D. C.
Universidad Central de Espana, Biblioteca; Madrid, Spain.
Universidad de Barcelona, Bibliotheca; Barcelona, Spain.
Universidad de Chile, Biblioteca; Santiago, Chile.
Universidad Literaria de Zaragoza; Zaragoza, Spain.
Universidad Mayor de San Marcos de Lima, Biblioteca; Lima, Peru.
Universidad Nacional, Bibliotheca; Buenos Aires, Argentine Republic.
Universidad Nacional, Bibliotheca; La Plata, Argentine Republic.
Universidade de Coimbra, Bibliothek; Coimbra, Portugal.
Università Commerciale Luigi Bocconi; Milan Italy.
Universitaet Leipzig, Bibliothek; Leipzig, Germany.
Universitaet Marburg, Bibliothek; Marburg, Germany.
Universitaet Montevideo, Biblioteca; Montevideo, Uruguay, South America.
Universitaet von Rostock, Bibliothek; Rostock, Germany.
Université de Bordeaux, Bibliothéque; Bordeaux, France.
Université de Grenoble, Bibliothéque; Grenoble, Isére, France.
Université de Liege, Bibliothéque; Liege, Belgium.
Université de Lille, Bibliothéque; Lille, France.
Université de Lyon, Bibliothéque; Lyon, France.
Université de Montpellier, Bibliothéque; Montpellier, France.
Université de Nancy, Bibliothéque; Nancy, France.
Université de Paris, Bibliothéque; Paris, France.
Université de Rennes, Bibliothéque; Rennes, France.
Université de Toulouse, Bibliothéque; Toulouse, France.
Universiteits Bibliotheek; Amsterdam, Netherlands.
Universite Libre de Bruxelles, Bibliotheque; Bruxelles, Belgium.
Universitatea din Bukarest, Bibliothek; Bukarest, Roumania.
University College Library; Auckland, New Zealand.
University of New Mexico; Albuquerque, New Mexico.
University of Vermont Library; Burlington, Vt.
University of Mexico Library; Mexico City, Mexico.
Verein fuer Geographie und Statistik; Frankfurt-am-Main, Prussia, Germany.
Verein fuer Naturkunde; Offenbach, Baden, Germany.
Verein fuer Naturwissenschaften; Braunschweig, Germany.
Verein z. Verbreitung Narutwissens chaftlicher Kenntnisse; Wien, Austria-Hungary.
Vereinigate Friedrichs-Universitaet, Bibliothek; Halle, Germany.

Victoria and Albert Museum; Bombay, India.
Victoria Institute; Port of Spain, Trinidad.
Victoria University Library; Toronto, Canada.
Virginia University Library; Charlottesville, Va.
Wagner Free Institute of Science; Philadelphia, Pa.
Washington Academy of Sciences; Washington, D. C.
Washington and Lee University Library; Lexington, Kentucky.
Washington Anthropological Society; Washington, D. C.
Washington Philosophical Society; Washington, D. C.
Washington University Library; Seattle, Washington.
Washington University Library; St. Louis, Mo.
Western Reserve University Library; Cleveland, Ohio.
Western State Normal School Library; Kalamazoo, Michigan.
Wisconsin Academy of Science; Madison, Wis.
Wisconsin University Library; Madison, Wis.
Worcester Natural History Society; Worcester, Mass.
Yale University Forestry School; New Haven, Conn.
Yale University Library; New Haven, Conn.
Yale University Observatory; New Haven, Conn.
Yorkshire Geological and Polytechnical Society, Halifax, England.
Zentral-Bibliothek; Munich, Germany.
Zoological Society; Fairmount Park, Philadelphia, Pa.
Zoologischer Anzeiger, Leipzig, Germany.
Zurich University Library; Zurich, Switzerland.

CONSTITUTION

OF

THE MICHIGAN ACADEMY OF SCIENCE.*

ARTICLE I.

This Society shall be known as "The Michigan Academy of Science."

ARTICLE II: Objects.

The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science.

ARTICLE III: Membership.

The Academy shall be composed of *Resident Members, Corresponding Members, Honorary Members, Patrons* and *Affiliated Societies.*

1. Resident Members shall be persons who are interested in scientific work and resident in the State of Michigan.

2. Corresponding Members shall be persons interested in science, and not resident in the State of Michigan.

3. Honorary Members shall be persons distinguished for their attainments in science, and not resident in the State of Michigan, and shall not exceed twenty-five in number.

4. Patrons shall be persons who have bestowed important favors upon the Academy, as defined in Chapter I, Paragraph 4 of the By-Laws.

5. Resident Members alone shall be entitled to vote and hold office in the Academy.

6. An affiliated society shall be a society accepted by the Council of the Academy, subject to ratification by the Academy at its next regular meeting as having as a principal object the promotion of scientific research in some line or lines, or the diffusion of scientific results in Michigan. Such a Society shall qualify as a member exactly as an individual member and shall exercise its right of membership through a delegate duly certified by the secretary of said society. Said delegate shall have all the rights of any resident member, except that the publications of the Academy shall be sent to the affiliated society as such as long as the dues of said society are paid and the secretary of the Academy not notified of the selection of a successor, and in case such society contains not less than eight resident members of the Academy such delegate shall ex-officio be a member of the Council of the Academy, as hereafter provided. And hereafter in this constitution and by-laws

*The history of the Academy will be found in the First Annual Report.

the word "Resident Member" shall be understood to include also said delegates, unless otherwise expressly stated.

ARTICLE IV: Officers.

1. The officers of the Academy shall consist of a President, a Vice President of each section that may be organized, a Secretary and a Treasurer.

These officers and all past presidents shall constitute an Executive Committee, which shall be called the Council.

2. The President shall discharge the usual duties of a presiding officer at all meetings of the Academy, and of the Council. He shall take cognizance of the acts of the Academy and of its officers, delegates of affiliated societies, containing a sufficient number of members of the Academy, as provided in Article III, and cause the provisions of the constitution and By-Laws to be faithfully carried into effect. He shall also give an address to the Academy at the closing meeting of the year for which he is elected.

3. The duties of the President in case of his absence or disability shall be assumed by one of the Vice Presidents who shall be designated by the Council.

The Vice Presidents shall be chairmen of their respective sections. They shall encourage and direct research in the special branches of science included within the Sections over which they preside.

4. The Secretary shall keep the records of the proceedings of the Academy and a complete list of the members, with the dates of their election and disconnection with the Academy. He shall also be the Secretary of the Council.

The Secretary shall co-operate with the President in attending to the ordinary affairs of the Society. He shall attend to the preparations, printing and mailing of circulars, blanks and notifications of elections and meetings. He shall superintend other printing ordered by the Academy, or by the President, and shall have charge of its distribution under the direction of the Council.

The Secretary, unless other provision be made, shall also act as *Editor* of the publications of the Academy and as *Librarian* and *Custodian* of property.

5. The Treasurer shall have the custody of all funds of the Academy. He shall keep an account of receipts and disbursements in detail, and this account shall be audited as hereinafter provided.

6. The Academy may elect an *Editor* to supervise all matters connected with the publication of the transactions of the Academy, under the direction of the Council, and to perform the duties of Librarian until such time as the Academy shall make that an independent office.

7. The Council is clothed with executive authority, and with the legislative powers of the Academy in the intervals between the latter's meetings; but no extraordinary act of the Council shall remain in force beyond the next following stated meeting, without ratification by the Academy. The Council shall have control of the publications of the Academy, under the provisions of the By-Laws and of the resolutions from time to time adopted. It shall receive nominations for members,

and on approval, shall submit such nominations to the Academy for action. It shall have power to fill vacancies *ad interim,* in any of the offices of the Academy.

8. Terms of Office. The President, Vice President, Secretary, Treasurer and Editor shall be elected annually, and be eligible to re-election without limitation. Delegates shall remain members of the Council as long as qualified, according to Article III.

ARTICLE V: Voting and Elections.

1. *All elections* shall be by ballot. To elect a Resident Member, Corresponding Member, Honorary Member or Patron or impose any special tax shall require the assent of three-fourths of all Resident Members voting.

2. Any member may be expelled by a vote of nine-tenths of all members voting, provided notice that such a movement is contemplated be given at a meeting of the Academy three months previous to such action.

3. Election of Members. Nominations for Resident membership shall be made by two Resident Members, according to a form to be provided by the Council. One of these Resident Members must be personally acquainted with the nominee and his qualifications for membership. The Council shall submit the nominations received by them, if approved, to a vote of the Academy at a regular meeting.

4. Election of Officers. Nominations for office shall be made by the Council as provided in the By-Laws. The nominations shall be submitted to a vote of the Academy at its winter [annual] meeting. The officers thus elected shall enter upon duty at the adjournment of the meeting.

5. At the meeting in which this constitution is adopted the officers for the ensuing year shall be elected in such manner as the academy may determine.

ARTICLE VI: Meetings.

1. The Academy shall hold at least two stated meetings a year—a *summer* [*or Field*] *Meeting*, and a *Winter* [*or Annual*] *Meeting*. The date and place of each meeting shall be fixed by the Council, and announced by circular at least three months before the meeting. The programme of each meeting shall be determined by the Council, and announced beforehand, in its general features. The details of the daily sessions shall also be arranged by the Council.

2. All members must forward to the Secretary, if possible, before the convening of the Academy, full title of all papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery and a brief abstract of their contents. From the abstracts thus presented, the Council will determine the fitness of the paper for the programme.

3. This section stricken out April 1, 1898.

4. Special Meeting of the Academy may be called by the Council, and must be called upon the written request of twenty Resident Members.

5. Stated Meetings of the Council shall be held coincidently with

the stated meetings of the Academy. Special meetings of the Council may be called by the President at such times as he may deem necessary.

6. Quorum. At meetings of the Academy a majority of those registered in attendance shall constitute a quorum. Four members shall constitute a quorum of the council.

ARTICLE VII: Publications.

The publications of the Academy shall be under the immediate control of the Council, but the Council shall accord to each author the right under proper restrictions, to publish through whatever channel he may choose.

ARTICLE VIII: Sections.

Members not less than eight in number may by special permission of the Academy unite to form a section for the investigation of any branch of science. Each section shall bear the name of the science which it represents, thus: The Section of (Agriculture) of the Michigan Academy of Science.

2. Each section is empowered to perfect its own organization as limited by the Constitution and By-Laws of the Academy.

ARTICLE IX: Amendments.

This Constitution may be amended at any winter [Annual] meeting by a three-fourths vote of all the Resident Members present.

BY-LAWS.

CHAPTER I: Membership.

1. No person shall be accepted as a Resident Member unless he pay the dues for the year within three months after notification of his election. An affiliated society, after the secretary has been notified that it will be accepted as affiliated shall also be expected to pay the annual dues, but a commutation of twenty-five dollars shall be accepted for a permanent membership. The annual dues shall be one (1) dollar, payable on or before the annual meeting in advance; but a single prepayment of twenty-five (25) dollars shall be accepted as commutation for life.

2. The sums paid in commutation of dues shall be invested, and the interest used for the ordinary purposes of the Academy during the payer's life, but after his death the sum shall be covered into the Research Fund.

3. An arrearage in payment of annual dues shall deprive a Resident Member of the privilege of taking part in the management of the Academy and of receiving the publications of the Academy. An arrearage

continuing over two (2) years shall be construed as notification of withdrawal.

4. Any person eligible under Article III of the Constitution may be elected Patron upon the payment of one hundred (100) dollars to the Research Fund of the Academy.

CHAPTER II: Officials.

1. The President shall countersign, if he approves, all duly authorized accounts and orders drawn on the Treasurer for the disbursement of money.

2. The Secretary, until otherwise ordered by the Academy, shall perform the duties of Editor, Librarian and Custodian of the property of the Society.

3. The Academy may elect an Assistant Secretary.

4. The Treasurer shall give bonds, with two good sureties approved by the Council, in the sum of five hundred dollars, for the faithful and honest performance of his duties, and the safe-keeping of the funds of the Academy. He may deposit the funds in bank at his discretion, but shall not invest them without the authority of the Council. His accounts shall be balanced on the first day of the Annual Meeting of each year.

5. The minutes of the proceedings of the Council shall be subject to call by the Academy.

CHAPTER III: Election of Members.

1. Nominations for Resident Membership may be proposed at any time on blanks to be supplied by the Secretary.

2. The *form* for the nomination of Resident Members shall be as follows:

In accordance with his desire, we respectfully nominate for Resident Member of the Michigan Academy of Science.

(Full name)

(Address)

(Occupation)

(Branch of science interested in, work already done, and publications, if any)

(Signed by at least two Resident Members.)

The form when filled is to be transmitted to the Secretary.

3. The Secretary shall bring all nominations before the Council at either the winter [Annual] or summer [Field] meeting of the Academy, and the Council shall signify its approval or disapproval of each. (The Secretary is delegated the power, by general action of the Academy, to accept, subject to the ratification of the Academy at its next meeting, applicants at any time upon the recommendation of two members, as now practiced, and upon the payment of one dollar, which shall cover the annual dues for the year in which it is paid, and that only.)

(Minutes, 1907.)

4. At the same or next stated meeting of the Academy, the Secretary shall present the list of candidates to the Academy for election.

5. Corresponding Members, Honorary Members, and Patrons shall be nominated by the Council, and shall be elected in the same manner as Resident Members.

CHAPTER IV: Election of Officers.

Section 1. At the Annual Meeting the election of officers shall take place and the officers elected shall enter on their duties at the end of the meeting.

Section 2. The Council shall nominate a candidate for each office, but each Section may recommend to the Council a candidate for its Vice President. Additional nominations may be made by any member of the Academy. All elections shall be made by ballot.

CHAPTER V: Financial Methods.

1. No pecuniary obligation shall be contracted without express sanction of the Academy or the Council. But it is to be understood that all ordinary incidental and running expenses have the permanent sanction of the Academy, without special action.

2. The creditor of the Academy must present to the Treasurer a fully *itemized* bill, *certified* by the official ordering it, and *approved* by the President. The Treasurer shall then pay the amount out of any funds not otherwise appropriated, and the receipted bill shall be held as his voucher.

3. At each annual meeting the President shall call upon the Academy to choose two members, not members of the Council, to whom shall be referred the books of the Treasurer, duly posted and balanced to the first day of the Annual Meeting as specified in the By-Laws, Chapter III, Paragraph 4. These Auditors shall examine the accounts and vouchers of the Treasurer, and any member or members of the Council may be present during the examination. The report of the Auditors shall be rendered to the Academy before the adjournment of the meeting and the Academy shall take appropriate action.

CHAPTER VI: Publications.

1. The publications are in charge of the Council and under their control, limited only as given by Article VII of the Constitution.

2. One copy of each publication shall be sent to each Resident Member, Corresponding Member, Honorary Member, and Patron, and each author shall receive fifty copies of his memoir. This provision shall not be understood as including publication in journals not controlled by the Academy, [By recent ruling, authors receive no reprints free. If reprints are wanted the academy will pay two-thirds if the author pays one-third the cost of printing not to exceed fifty copies. The author may have as many more than fifty provided he bears the whole expense of those above fifty.] (Minutes of 1906.)

CHAPTER VII: The Research Fund.

1. The Research Fund shall consist of moneys paid by the general public for publications of the Academy, of donations made in aid of research, and of the sums paid in commutation of dues according to the By-Laws, Chapter I, Paragraphs 2 and 4.

2. Donors to this fund not members of the Academy, in the sum of twenty-five dollars, shall be entitled without charge to the publications subsequently appearing.

CHAPTER VIII. Order of Business.

1. The order of business at the Winter [Annual] Meetings shall be as follows:

(1) Call to order by the presiding officer.
(2) Introductory ceremonies.
(3) Statements by the President.
(4) Report by the Council.
(5) Report of the Treasurer, and appointment of the Auditing Committee.
(6) Election of officers of the next ensuing administration.
(7) Election of members.
(8) Announcement of the hour and place for the address of the retiring President.
(9) Necrological notices.
(10) Miscellaneous announcements.
(11) Business motions and resolutions, and disposal thereof.
(12) Reports of committees and disposal thereof.
(13) Miscellaneous motions and resolutions.
(14) Presentation of memoirs.

2. At an *adjourned session,* the order shall be resumed at the place reached on the previous adjournment, but new announcements, motions and resolutions will be in order before the resumption of the business pending at the adjournment of the last preceding session.

3. At the *Summer* [*Field*] *Meeting* the items of business under numbers (5), (6), (8), (9), shall be omitted.

4. At any *Special Meeting* the Order of Business shall be (1), (2), (3), (7), (10), followed by the special business for which the meeting was called.

CHAPTER IX: Amendments.

These By-Laws may be amended by a majority vote of the members present at any regular meeting.

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